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THIS REPORT PRESENTS THE FINDINGS OF A DETAILED SOIL MAPPING AND CHARACTERIZATION PROJECT ON RMA. THE OBJECTIVES OF THE STUDY INCLUDE:

1. DESCRIPTION AND CHARACTERIZATION OF THE PHYSICAL, CHEMICAL, AND MINERALOGICAL ATTRIBUTES OF THE SOIL
2. EVALUATION OF BASIC SOIL DATA TO PROVIDE INTERPRETATIONS IMPORTANT TO USE, MANAGEMENT, AND REMEDIATION
3. DETERMINATION AND MAPPING OF THE DISTRIBUTION OF THE SOILS.

THE REPORT INCLUDES THE FOLLOWING SECTIONS:

1. DISCUSSION OF FIELD PROCEDURES AND INTERPRETATION METHODS
2. DETAILED DESCRIPTION OF SOIL SERIES
3. PHYSICAL AND HYDROLOGIC PROPERTIES - TEXTURE, HYDRAULIC CONDUCTIVITY
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Environmental Scientists

SOIL INVESTIGATION AND INVENTORY OF THE ROCKY MOUNTAIN ARSENAL

Adams County, Colorado

19 October 1988

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Adams County, Colorado

1.0 INTRODUCTION

The Rocky Mountain Arsenal (RMA) is a federal reservation under the jurisdiction of the United States Army and occupies approximately 17,000 acres in western Adams County, Colorado (Figure 1). The RMA was originally mapped as part of the soil survey of Adams County (Sampson and Baber, 1974) This report presents the findings of a detailed soil mapping and characterization project on the Arsenal. It includes a discussion of methods and results, interpretations of the soils and map units for various uses, a soil map and appendices. This work was performed by James P. Walsh & Associates, Inc. under contract to Morrison-Knudsen Engineers, Inc.

1.1 Purpose

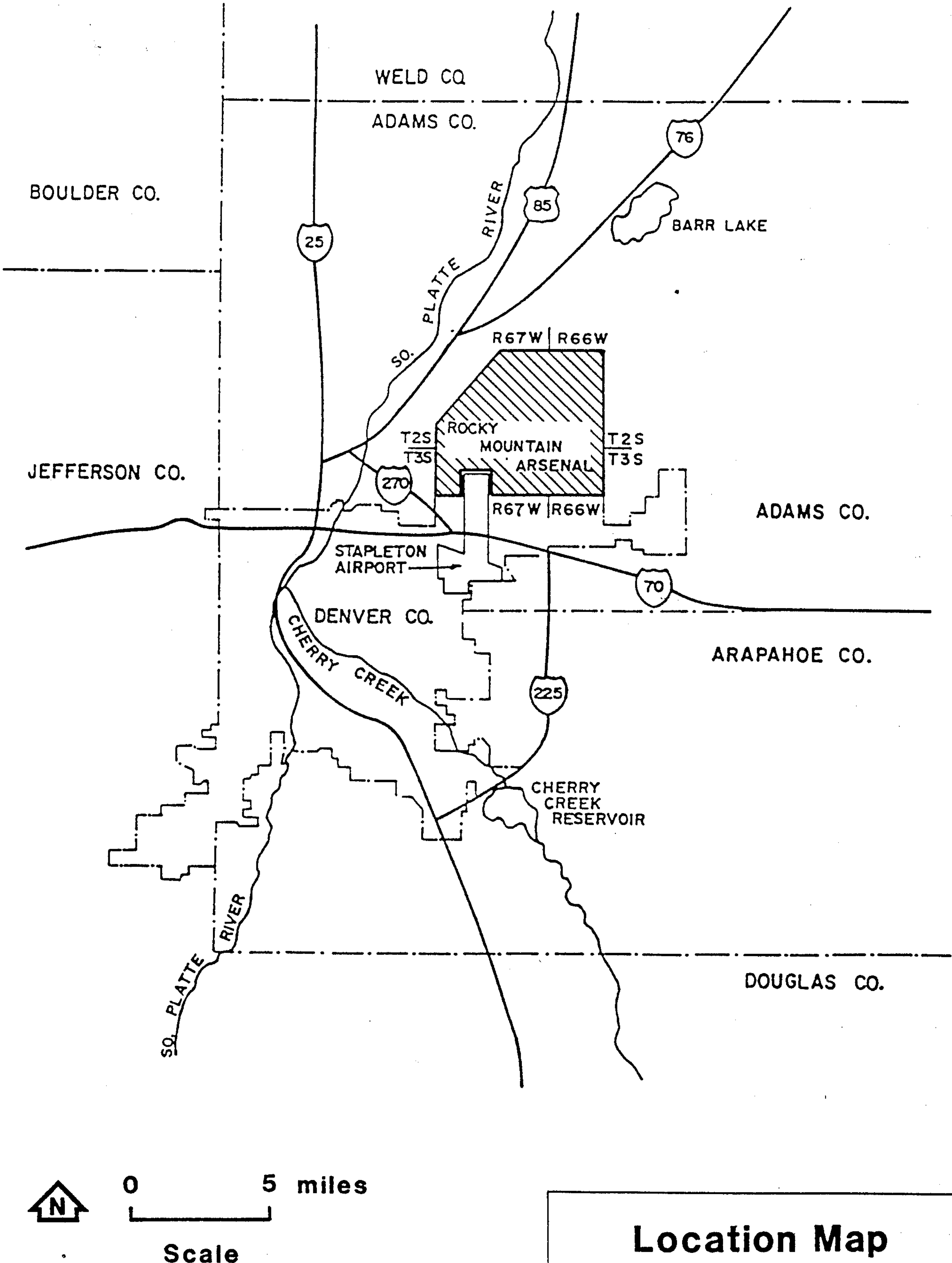
The goal of this project was to obtain detailed information about the soils of the RMA. The formulation and implementation of soil related remedial actions would require greater precision than is normally found in standard Soil Conservation Service (SCS) county soil surveys, so a detailed investigation was authorized. The project was initiated in response to the need for detailed soils information to support the research, remediation and management activities on the RMA. The specific objectives include:

1. Description and characterization of the physical, chemical and mineralogical attributes of the soil.

2. Evaluation of basic soil and landscape data to provide interpretations important to use, management and remediation.

3. Determination and mapping of the distribution of the soils.

Location Map



Location Map

James P. Walsh & Associates, Inc. | **Figure 1**

1.2 Scope of Work

This Investigation involved the detailed description of over 250 soils, the collection and laboratory characterization of about 40 soil profiles and the examination and classification of nearly 1200 undisturbed soil cores. The description, collection and examination of the soils was performed by James P. Walsh and Lewis P. Munk of James P. Walsh & Associates., Inc.

This investigation meets the requirements of an Order 1 soil survey as defined in the Soil Survey Manual (Soil Survey Staff, 1981) . An order 1 soil survey restricts the maximum proportion of limiting dissimilar soil inclusions in map units to 10 percent. A limiting dissimilar soil is one which varies in properties from the mapped soil, to the extent that management or interpretations are significantly effected.

The map unit used in this inventory were consociations and complexes of phases of soil series and an undifferentiated group of disturbed areas and miscellaneous landtypes. Spot symbols were used where limiting dissimilar soils were too small to delineate. A typical pedon of each major soil was described in detail with accompanying laboratory data in this report. The range of characteristics for selected parameters for each major soil was provided.

2.0 METHODS

2.1 Field Procedures

This inventory proceeded in two fairly distinct stages. The first stage involved the identification, description and characterization of the dominant soils and the development of appropriate map units for the survey area. The second stage comprised mapping the distribution of the soils.

The soils were identified, described and characterized using the procedures and nomenclature outlined in the Soil Survey Manual (Soil Survey Staff, 1981). Soil profiles were evaluated in backhoe pits and as undisturbed cores. The soils were classified in the field to the family level using Soil Taxonomy (Soil Survey Staff, 1975). Official SCS soil series descriptions were consulted to classify the soils to the series level where practical. A few soils were not classified to the series level since they had properties outside the limits of locally recognized soil series and occupied a minor proportion of the area. These soils were classified to the phase of family level. Soil samples were collected for laboratory analysis to support the field evaluations and to provide additional information about the soils.

Map units were developed specifically to support the desired interpretations and uses of the soil survey. For example, soil and landscape properties which potentially influence plant growth, soil erosion by wind and water and the retention and transport of contaminants were considered in developing map units. Most map units were consociations of surface texture and slope phases of soil series or soil families (e.g. Bresser sandy loam, 0 to 1 % slopes). However, a soil complex (e.g. Bresser-Satanta sandy loam complex, 0 to 1 % slopes) was used where the soil pattern of similar soils was intricate and delineating the soils would needlessly complicate the map. An undifferentiated group composed of soil and non-soil components and miscellaneous landtypes was used in drastically disturbed areas. These disturbed lands map units were phased based on the soil texture (e.g. Disturbed land sandy).

The second stage of the survey involved mapping the distribution of the soils. This task was accomplished by examining hundreds of soil cores from all sections of the Arsenal. The locations of soil observations were selected to represent the range of possible geomorphic positions occurring in a geographically limited area. This method of is a standard soil survey procedure and was used in this survey since soil boundaries on the RMA corresponded well with changes in landscape position. In areas with no perceptible landscape change, observations were made at arbitrary distance intervals. This allowed the development of a qualitative, location sensitive model relating soils to landscape position and vegetation. This conceptual model was tested and corrected for geographic variation as the mapping progressed and relationships changed. The number of observations varied with the complexity of the soil pattern and ranged from 40 and 70 observations per section.

Soil samples for laboratory analyses were collected from backhoe pits and undisturbed soils cores. Soil core tubes and other sampling equipment were decontaminated between samples and/or sites. The appropriate chain of custody and surety procedures were followed during sample handling and delivery to the laboratory.

2.2 Laboratory Procedures

Laboratory analyses were performed to assess the physical, chemical and mineralogical attributes of the soils. The procedures for determining the soil physical and chemical properties are referenced in Appendix A. These analyses were performed by Colorado Analytical Laboratory, Brighton, Colorado.

The clay mineralogy of selected soils was determined using x-ray diffraction by the Sedimentology Lab, Institute for Arctic and Alpine Research, University of Colorado-Boulder. The methods used are cited in Appendix C.

2.3 Interpretation Methods

Interpretations were made for each soil and map unit. Soil interpretations were derived using soil properties from field and laboratory data and established relationships. Available water holding capacity and hydraulic conductivity are examples of soil interpretations. Map unit interpretations were based the properties of the dominant soil(s) in combination with other landscape parameters. The determination of revegetation potential for example was made by considering several soil and landscape parameters.

Interpretations were based primarily on guidelines developed by the Soil Conservation Service, though other sources were consulted. The sources used in making the interpretations are listed in Appendix B.

3.0 RESULTS AND DISCUSSION

3.1 Soil Forming Factors

3.1.2 Geology and Parent Materials

The soils of the Rocky Mountain Arsenal were formed almost entirely from wind and water transported materials. These materials overlie a great thickness of sedimentary rocks which have little genetic relationship to the present soils. The alluvial materials were derived from shales, sandstones and granitic rocks eroded and deposited by the South Platte River and its tributaries. Most of the alluvial materials are medium to fine textured, though small remnants of cobbly alluvium occur on Rattlesnake and Henderson Hills and in the North Plants area. The wind deposited materials are mostly sands carried from old stream channels and floodplains. These sands were probably derived from sandstones and coarse grained igneous rocks eroded from the Front Range during the last glaciation. Morrison-Knudsen Engineers, Inc. (1988) provides a review and description of the geologic environment of the Arsenal.

3.1.2 Physiography

The land surface of the Arsenal has been largely shaped by fluvial processes associated with the South Platte River and its tributaries. The alluvial processes resulted in the nearly level to gently sloping old alluvial terraces that dominate the landscape and associated steeper sloped terrace escarpments. Sandy eolian deposits mantle and obscure the original alluvial land surface in many areas. These eolian deposits are thickest and most prominent in the south and west sections of the survey area. Landforms in the eolian areas include obvious stabilized old sand dune features, ridges and blowouts and more subtle water-reworked eolian plains with poorly integrated and partially buried drainage channels. Slopes gradients on the RMA are dominantly 0 to 3 percent with smaller areas of steeper slopes ranging up to about 10 percent. Soil types vary with subtle physiographic changes encountered on the Arsenal.

3.1.3 Time

The soils of the Arsenal vary in age as evidenced by their various degrees of development. The youngest soils are associated with recent (Piney and post-Piney Creek) fluvial and slopewash activity and possess surface horizons which have accumulated organic matter (mollic epipedons), but have subsurface horizons with minimal or no development. These soils are roughly a hundred to several thousand years old.

Intermediate aged soils have subsurface horizons in which clay and calcium carbonate (argillic and calcic) have accumulated through the processes of illuviation and reprecipitation. The age of these soils was inferred from the magnitude of the accumulations and the depth, thickness and distinctness of the horizons and comparison to studies of other soils (Birkeland, 1974; Gile, 1974; Gile and Grossman, 1979; Nettleton et al, 1975; Reheis, 1978; Southard and Southard, 1985). They range in age from early Holocene (7000 years ago) to late-Wisconsin (15,000 to 20,000 years ago). A heavy textured, calcareous buried soil horizon was frequently encountered below the present B and C horizons. This buried soil horizon has properties which suggest that the landscape was stable for a relatively long period of time prior to being truncated and buried by the present soils.

The oldest recognizable soil feature on the Arsenal is the calcium carbonate cemented alluvial cobbles on Rattlesnake and Henderson Hills and in the North Plants area. This horizon meets the requirements of a petrocalcic horizon as defined in Soil Taxonomy. The materials this horizon formed from may have been deposited during the Kansan age, up to 600,000 years ago (Morrison - Knudsen Engineers, Inc., 1988). This ancient petrocalcic horizon is overlain by soils formed in material which is probably much younger.

3.1.4 Climate

The climate of the Arsenal is continental with cold winters and hot summers. The mean annual precipitation is about 15 inches, with nearly 65 percent coming as rain during the growing season. The frost free period is about 160 days with the last freeze in the spring occurring around May 5 and the first freeze of the fall around October 12. The mean monthly precipitation and temperature for the Denver AP station are listed in table 1.

Temperature partly determines the rate at which most chemical, physical and biological processes occur in the soil. Soil temperature varies with depth and in response to air temperature fluctuations. Diurnal and seasonal soil temperature fluctuations decrease with increasing depth. Soil temperature data was not collected as part of this study, but can be estimated from relationships developed elsewhere. The soil temperature regime was estimated to be mesic, indicating that the mean annual soil temperature at a depth of 20 inches is between 47^{o} and 59^{o}F. The mean annual soil temperature for a well-drained, gently sloping soil is probably near 50^{o}F.

The soil moisture regime of the soils on the Arsenal was estimated to be ustic with typic, aridic and aquic intergrades. The ustic soil moisture regime implies that soil water is available during the growing season. Most of the soils on the Arsenal have aridic intergrades which, suggest that they are on the dry end of the spectrum for ustic soils. The depth to lime and observations in the field following summer precipitation events supports this classification. A small proportion of the soils occur in swales and were placed in typic subgroups which are wetter than the aridic subgroups since they receive run-on. The aquic subgroups are saturated with water for short periods of time during the year as a result of their proximity to water sources and position on the landscape.

Table 1. Mean monthly and mean annual precipitation (in) and air temperature (^{o}F) for the Denver AP station. Adapted from Siemer (1977).

Month	J	F	M	A	M	J	J	A	S	O	N	D	ANN.
Precip	0.6	0.7	1.2	1.8	2.5	1.9	1.7	1.3	1.3	1.0	0.8	0.5	15.3
Temp	30	33	37	48	57	67	73	72	63	52	39	32	50.1

3.1.5 Biologic Influences

Vegetation has had a profound effect on the genesis of the Arsenal soils. The dominant vegetation type in this region throughout the Holocene was a short grass prairie (Daubenmire 1978). The prairie vegetation resulted in the formation of moderately thick, humus rich surface horizons (mollic epipedons) throughout the region. Mollic epipedons occur in almost all the soils of the Arsenal, except those that have been severely disturbed. Burrowing and grazing animals and soil insects and micro-organisms also effect soil formation, but their influence is difficult to gauge.

3.2 Soil Classification

The soils were classified to the family level using Soil Taxonomy (Soil Survey Staff, 1975) and local conventions. Table 2 lists the soils by series or subgroup name and provides their classification to the family level.

Table 2. Classification of Soils.

Soil Name	Family	Subgroup
Ascalon	Fine-loamy, mixed, mesic	Aridic Argiustolls
Bresser	Fine-loamy, mixed, mesic	Aridic Argiustolls
Haplustolls	Fine-loamy, mixed, mesic	Aquic Haplustolls
Haplustolls	Fine-loamy, mixed, mesic	Typic Haplustolls
Nunn	Fine, montmorillonitic, mesic	Aridic Argiustolls
Paleustolls	Coarse-loamy, mixed, mesic	Petrocalcic Paleustolls
Satanta	Fine-loamy, mixed, mesic	Aridic Argiustolls
Truckton	Coarse-loamy, mixed, mesic	Aridic Argiustolls
Weld	Fine, montmorillonitic,mesic	Aridic Paleustolls

3.3 General Distribution of the Soils

The detailed soil map was used to construct a small scale map depicting the distribution of soil associations on the Arsenal. Figure 2 is the General Soil Map and shows the distribution of the five soil associations.

1. **Bresser-Truckton Association:** Soils formed in medium to coarse textured, late-Wisconsin to early Holocene eolian deposits. Depth to lime is usually greater than 40 inches. Surface soil textures are loamy sands and sandy loams, subsurface textures are sandy loams and sandy clay loams. These soils are well drained and have slopes ranging from 0 to 10 percent.

2. **Ascalon-Satanta Association:** Soils formed in medium to coarse textured, late-Wisconsin to early Holocene alluvium and windblown deposits. Depth to lime is less than 30 inches. Surface soil textures are sandy loams and loams, subsurface textures are sandy clay loams and clay loams. These soils are well drained and have slopes ranging from 0 to 10 percent.

3. **Weld-Nunn Association:** Soils formed in medium to fine textured, late-Wisconsin alluvium and windblown deposits. Depth to lime is from 12 to 35 inches. Surface textures are loams and clay loams, subsurface textures are clay loams and clays. These soils are well drained and have slopes ranging from 0 to 3 percent.

4. **Aquic Haplustolls (Wet Areas):** Soils formed in medium to coarse textured, Holocene alluvium and windblown deposits that have characteristics related to seasonal saturation by water. Surface textures are sandy loams and loams, subsurface textures are sandy loams, loams and clay loams. These soils are somewhat poorly to poorly drained and have slopes ranging from 0 to 3 percent.

5. **Bresser-Satanta Association:** Soils formed in medium to coarse textured, late-Wisconsin to early Holocene alluvium and water reworked eolian deposits. Depth to lime is greater than 40 inches. Surface textures are sandy loams, subsurface textures are sandy clay loams and clay loams. These soils are well drained and have slopes ranging from 0 to 3 percent.

General Soil Map

Soil Associations

1– Bresser/Truckton

2– Ascalon/Satanta

3– Weld/Nunn

4– Aquic Haplustolls

5– Bresser/Satanta

Scale

0 miles 1

N

Rocky Mountain Arsenal
Adams County, Colorado

James P. Walsh & Associates, Inc.

Figure 2

3.4 Description of the Soils and Map Units

3.4.1 Aquic Haplustolls

The Aquic Haplustolls consist of deep, somewhat poorly drained and poorly drained soils formed in medium textured, Holocene alluvium. They occur on nearly level (0 to 3 percent slopes) alluvial terraces, floodplains and depressional areas. These soils occur mostly near First Creek and are not extensive.

Pedon # 46 is a typical profile of a fine-loamy, mixed, mesic Aquic Haplustoll and is located 1750 feet east and 600 feet south of the northwest corner of the northwest 1/4 of section 31, T2S, R66W.

A-- 0-6" brown (10YR 4/3) loam, very dark gray brown (10YR 3/2) moist; strong medium granular structure; slightly hard, friable; neutral (pH 7.3); clear smooth boundary; common fine to medium roots; common fine pores.

AC-- 6-11" brown (10YR 4/3) sandy clay loam, dark brown (10YR 3/3) moist; moderate fine subangular blocky structure; slightly hard, very friable; mildly alkaline (pH 7.8); slightly effervescent; clear smooth boundary; common fine to medium roots; few fine to medium pores.

C1-- 11-16" pale brown (10YR 6/3) sandy clay loam, dark gray brown (10YR 4/2) moist; few fine distinct mottles; moderate medium subangular blocky structure; slightly hard, very friable; moderately alkaline (pH 7.9); slightly effervescent ; clear smooth boundary; few fine to medium roots; few fine to medium pores.

C2-- 16-41" dark gray brown (10YR 4/2) moist fine sandy loam; few fine distinct mottles; massive; slightly hard, very friable; moderately alkaline (pH 8.1); slightly effervescent; clear smooth boundary; few medium to coarse and common fine roots; common fine to medium and many very fine pores.

C3-- 41-54" dark brown (10YR 3/3) sandy loam moist; massive; slightly hard, very friable; very strongly alkaline (pH 8.4); slightly effervescent; clear smooth boundary; few very fine to fine roots; few very fine pores.

C4-- 54-62" brown (10YR 4/3) moist sandy loam; common medium faint mottles; massive; slightly hard, very friable; few fine roots; common very fine pores.

The A horizon ranges from 6 to 20 inches in thickness and from sandy loam to clay loam in texture. The B horizon, if present, is 7 to 30 inches thick and ranges in texture from sandy loam to silty clay. The clay content ranges from 16 to 43 percent, but the weighted average in the control section is less than 35 percent. Depth to lime ranges from 6 to more than 60 inches. The calcium carbonate equivalent ranges from 0.3 to nearly 30 percent. Mottles commonly occur in the B and C horizons. The seasonally high water table in some of these soils is related to drainage from canals and impoundment structures.

The Aquic Haplustolls are similar to the Ascalon, Bresser and Satanta soils, except that they lack an argillic horizon and may be saturated with water within 40 inches of the soil surface at some time during the year. The Aquic Haplustolls are similar to the Typic Haplustolls, except that they are saturated with water within 40 inches of the soil surface at some time during the year.

Aquic Haplustolls sandy loam - loam, 0-1% slopes (Fa).

This map unit consists of soils which have properties related to a seasonally high water table. Surface horizon texture is sandy loam and a coarse textured loam. Slopes are dominantly 0 to 1 percent with small areas ranging up to 3 percent. It is mapped primarily on the floodplain and low terraces of First Creek, but also occurs near and as a result of water impoundment, diversion and conveyance structures. Soil horizonation in this map unit is variable because of the recent alluvial origin of the soil. The weighted average clay content in the control section is between 18 and 35 percent, though both finer and coarser textured layers may occur. This map unit contains small inclusions of soils similar in texture to the Nunn near the water treatment plant in section 24. It also contains small inclusions of Aquolls, most of which are marked with a wet spot symbol. Also included are soils with the characteristics of the Bresser soils with an induced water table.

3.4.2 Ascalon Series

The Ascalon series consists of deep, well drained soils formed in medium to coarse textured, late-Wisconsin and early Holocene alluvial and eolian deposits. They occur on nearly level to strongly sloping (0 to 10 percent slopes), old alluvial terraces and terrace escarpments and eolian plains. These soils are extensive throughout the Arsenal.

Pedon # 79 is a typical profile of the Ascalon sandy loam and is located 500 feet east and 500 feet north of the southwest corner of the northwest 1/4 of section 9, T3S, R67W. The Ascalon series is a member of the fine-loamy, mixed, mesic Aridic Argiustolls.

A-- 0-7" brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, loose; neutral (pH 6.7); clear smooth boundary; common fine roots; many very fine pores; 2 percent gravel.

Bt-- 7-24" yellowish brown (10YR 5/4) sandy clay loam, dark yellowish brown (10YR 4/4) moist; moderate to strong coarse subangular blocky structure; hard, firm; mildly alkaline (pH 7.4); clear smooth boundary; common very fine roots; few very fine pores; many moderately thick clay films on ped faces.

Bk-- 24-44" pale brown (10YR 6/3) sandy loam, yellowish brown (10YR 5/4) moist; moderate coarse subangular blocky structure; slightly hard, very friable; strongly alkaline (pH 8.5); strongly effervescent; gradual smooth boundary; few very fine roots; few coarse and common very fine pores; few thin clay films in pores; about 1 percent gravel.

C-- 44-67" pale brown (10YR 6/3) sandy loam; brown (10YR 5/3) moist; massive; slightly hard, very friable; strongly alkaline (pH 8.6); slightly effervescent; few very fine roots; few very fine pores; about 1 percent gravel.

The A horizon ranges from loamy sand to sandy clay loam in texture and from 5 to 14 inches in thickness. The Bt horizon is 8 to 25 inches thick and ranges in texture in some parts from sandy loam to sandy clay. The clay content is commonly 28 to 30 percent, but ranges from 20 to 38 percent. Depth to lime ranges from 8 to 30 inches, but may occur at or near the surface in disturbed areas. The calcium carbonate equivalent ranges from 0.3 to over 21 percent; it normally increases with depth to a maximum then decreases. The C horizon varies in texture from loamy sand to sandy clay loam, and these layers are usually calcareous. Fine textured, calcareous, buried soil horizons may occur below 40 inches. Minor amounts (less than 10 percent) of rounded gravels and small cobbles may occur in and on the surface of these soils near Rattlesnake and Henderson Hills and the North Plants area.

The Ascalon soils are similar to the Bresser soils, except that lime occurs higher in the profile. The Ascalon soils are similar to the Satanta soils, except that they contain a higher proportion of sands coarser than very fine sands in the control section.

Ascalon sandy loam, 0-1% and 1-3% slopes (AsA and AsB).

These map unit consists of Ascalon soils with sandy loam surface horizons. They occur on old alluvial terraces with slopes of 0 to 1 and 1 to 3 percent. Weld and Nunn soils may occur as dissimilar inclusions in the northern and eastern half of the Arsenal. Aquic Haplustolls may occur as inclusions in the area of First Creek and Upper Derby Lake.

Ascalon sandy loam, 3-6% and 6-10 % slopes (AsC and AsD).

These map units consist of Ascalon soils with sandy loam surface horizons. They occurs on old alluvial terrace escarpments along First Creek and in the Rattlesnake and Henderson Hills and North Plants area. The Ascalon soils in this map unit may contain small amounts of gravel and cobbles in and on their surface horizons. Weld and Nunn soils may occur as dissimilar inclusions in the northern and eastern sections of the Arsenal.

3.4.3 Bresser Series

The Bresser series consists of deep, well drained soils formed in medium to coarse textured, late Wisconsin and early Holocene eolian deposits. In some areas these deposits have been reworked by water. They occur on nearly level to undulating (0 to 10 percent slopes) sandy eolian plains and old sand dunes mantling older alluvial terraces. These soils are extensive throughout the Arsenal.

Pedon # 1-41 is a typical profile of the Bresser sandy loam and is located 400 feet east and 450 south of the southwest corner of the northwest 1/4, section 1, T3S, R67W. The Bresser series is a member of the fine-loamy, mixed, mesic Aridic Argiustolls.

A-- 0-8" brown (10YR 4/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; soft, very friable; neutral (pH 6.7); clear smooth boundary; few very fine roots; many very fine vesicular pores.

Bt-- 8-24" brown (10YR 4/3) moist sandy clay loam; moderate medium subangular blocky structure; slightly hard, friable; neutral (pH 7.1); clear smooth boundary; few medium roots; few fine tubular pores; many moderately thick clay films.

C-- 24-46" yellowish brown (10YR 5/4) moist loamy sand; weak medium subangular blocky structure; soft, very friable; mildly alkaline (pH 7.5); abrupt smooth boundary; many very fine vesicular pores.

Ck-- 46-50" yellowish brown (10YR 5/4) moist loamy sand; weak medium subangular blocky structure; soft, very friable; mildly alkaline (pH 7.6); strongly effervescent; clear boundary; many very fine vesicular pores.

2Ck-- 50-60" brown (10YR 4/3) moist loam; moderate fine angular blocky structure; slightly hard, very friable; mildly alkaline (pH 7.5); strongly effervescent; 2 percent gravel.

The A horizon ranges from loamy very fine sand to coarse sandy loam in texture and from 5 to 19 inches in thickness. The Bt horizon is 5 to 29 inches thick and ranges in texture from sandy loam to sandy clay. The clay content is commonly 22 to 27 percent, but ranges from 16 to 38 percent. Depth to lime ranges from 30 to greater than 60 inches. The calcium carbonate equivalent ranges from 0.5 to about 20 percent. Lime generally occurs below the Bt horizon. The C horizon varies in texture from coarse sand to sandy clay loam. Fine textured, calcareous, buried soil or alluvial horizons may occur below about 36 inches. The sand fraction and soil texture of the Bresser tends to be coarser in the south and west parts of the study area and near the ridges of well defined sand dune landforms than in other areas of the Arsenal or landscape positions. These coarser textured Bresser soils generally have lime deeper in the profile, ranging from 50 to greater than 60 inches rather than 30 to 50 inches common in other areas. The Bresser soils mapped in complex with Satanta soils in the southern portion of the Arsenal have less sand and sands that are finer than typical and have a greater depth to lime.

The Bresser soils are similar to the Truckton soils, except that they have more clay in the Bt horizons. The Bresser soils are similar to the Ascalon, except that lime occurs lower in the profile. The Bresser soils are similar to the Satanta soils, except that they contain a higher proportion of sands coarser than very fine sand in the control section.

Bresser sandy loam, 0-1% and 1-3% slopes (BrA and BrB).

These map units consist of Bresser soils with sandy loam surface horizons. They occur on sandy eolian plains and old water-reworked sand dune fields with slopes of 0 to 3 percent. Slopes in these map units are commonly undulating. These map units are extensive, particularly in the southern half of the Arsenal. Weld and Nunn soils may occur as dissimilar inclusions in the northern and eastern part of the Arsenal. The depth to lime is shallower, the texture finer and the probability of encountering a buried alluvial layer is greater near the northern extent of the main Bresser delineations.

Bresser sandy loam, 3-6% and 6-10% slopes (BrC and BrD).

These map units consist of Bresser soils with sandy loam surface horizons. They occur on old sand dune landforms and sand mantled alluvial escarpments with slopes of 3 to 10 percent. The slopes are commonly complex since they may include both the convex ridgetop and concave sideslopes and toeslopes of the dunes. Most delineations are relatively small and narrow. These map units are not extensive. Nunn soils are included as minor dissimilar inclusions in the northwestern part of the Arsenal.

Bresser-Satanta sandy loam complex, 0-1% and 0-3% slopes (BsA and BsB).

These map units consist of a complex of Bresser and Satanta soils with sandy loam surface horizons. The Bresser soils occupy about 70 percent and the Satanta soils about 30 percent of the map unit. They occur on old water reworked sandy eolian plains and old dune fields. The Satanta soils in these delineations are deeper to lime than typical, and the Bresser soils have less coarse sand than typical of these series elsewhere on the Arsenal. The Satanta soils occur in small concave areas and the Bresser soils occur in the higher landscape positions. These units are mapped in the southeastern part of the Arsenal in large delineations. They are moderately extensive.

3.4.4 Nunn Series

The Nunn series consists of deep, well drained soils formed in medium to fine textured, late-Wisconsin alluvium and wind-deposited materials. They occur on nearly level to undulating (0 to 6 percent slopes) old alluvial terraces. These soils are moderately extensive in the north and east portions of the Arsenal.

Pedon # 17 is a typical profile of the Nunn clay loam and is located 700 feet east and 600 feet north of the southwest corner of the southeast 1/4 of section 23, T2S, R67W. The Nunn series is a member of the fine, montmorillonitic, mesic Aridic Argiustolls.

A-- 0-2" brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate coarse platy structure; slightly hard, very friable; neutral (pH 7.2); clear smooth boundary; common very fine roots; few very fine pores.

AB-- 2-8" brown (10YR 5/3) clay loam, very dark gray (10YR 3/3) moist; moderate coarse platy structure; hard, friable; neutral (pH 7.2); abrupt smooth boundary; few very fine roots; few very fine pores; 1 percent gravel.

Bt-- 8-14" pale brown (10YR 6/3) clay, brown (10YR 4/3) moist; strong medium subangular blocky structure; hard, firm; mildly alkaline (pH 7.7); clear wavy boundary; few very fine roots; few very fine tubular pores; few thin clay films.

Btk1-- 14-27" yellowish brown (10YR 5/4) clay loam, brown (10YR 5/3) moist; strong medium angular blocky structure; hard, firm; moderately alkaline (pH 8.2); slightly effervescent; clear wavy boundary; few very fine roots; common very fine pores; common moderately thick clay films.

Btk2-- 27-33" pink (7.5YR 7/4) clay loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.3); slightly effervescent; gradual smooth boundary; few very fine roots; common very fine tubular pores; common moderately thick clay films; 1 percent gravel.

Ck1-- 33-47" pink (7.5YR 7/4) sandy clay loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.4); slightly effervescent ; clear irregular boundary; few very fine roots; common very fine tubular pores; 1 percent gravel.

Ck2-- 47-69" pink (7.5YR 7/4) sandy clay loam, brown (7.5YR 5/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.4); strongly effervescent; common very fine pores.

The A horizon ranges from 4 to 18 inches in thickness and from fine sandy loam to silt loam in texture. The Bt horizon is 8 to 32 inches thick and ranges in texture in some part from sandy clay loam to silty clay. The clay content is commonly 38 to 42 percent, but ranges from 32 to 50 percent. Depth to lime varies from 8 to 35 inches, but may occur at or near the surface in disturbed areas. The calcium carbonate equivalent ranges from 0.3 to nearly 20 percent and is commonly concentrated in the lower part of or just below the Bt horizon. Buried soil horizons and texturally contrasting alluvial layers may occur below about 40 inches.

The Nunn soils are similar to the Weld soils, except that they have a gradual textural boundary between the A and Bt horizons, and more sands coarser than very fine sand in the control section. The Nunn soils are similar to the Satanta soils, except that they have more clay in the Bt horizon.

Nunn clay loam, 0-1% and 0-3% slopes (NuA and NuB).

These map units consist of Nunn soils with clay loam surface horizons. They occur on old alluvial terraces with slope gradients of 0 to 1 and 1 to 3 percent. Most of these map units occur as large delineations on planar surfaces associated with Weld soils in the northern portion of the Arsenal. A minor amount was mapped as small delineations in concave depressions associated with Bresser soils in the west central portion of the Arsenal. The depth to lime is deeper than typical for the Nunn series in the soils mapped in depressions. Bresser, Ascalon and Satanta soils may occur as dissimilar inclusions in the northern part of the Arsenal. Aquic Haplustolls may occur as inclusions where Nunn is mapped along First Creek.

3.4.5 Petrocalcic Paleustolls, coarse-loamy, mixed, mesic.

The Petrocalcic Paleustolls consist of moderately deep, well drained soils formed in gravely, Pleistocene alluvium and coarse to medium textured late-Wisconsin and Holocene wind deposited materials. They occur on nearly level to strongly sloping (0 to 10 percent slopes) old alluvial terrace remnants. These soils occur on Rattlesnake and Henderson Hills and in the North Plants area and are of minor extent.

Pedon # 36-32 is a typical profile of a fine-loamy, mixed, mesic Petrocalcic Paleustoll and is located 1250 feet east and 40 feet south of the northwest corner of the northwest 1/4 of section 36, T2S, R67W.

A-- 0-7" brown (10YR 4/3) sandy loam, dark brown (10YR 3/3) moist; weak fine granular structure; soft, very friable; mildly alkaline (pH 7.6); clear smooth boundary; common very fine roots; common fine vesicular pores; 5 percent gravel.

Bw-- 7-23" dark yellowish brown (10YR 4/4) sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; soft, very friable; mildly alkaline (pH 7.7); abrupt smooth boundary; few fine roots few very fine tubular pores; few thin clay films; 5 percent gravel.

Ck-- 23-30" very pale brown (10YR 7/3) gravelly sandy loam, pale brown (10YR 6/3) moist; single grained; loose, very friable; mildly alkaline (pH 7.7); violently effervescent; abrupt smooth boundary; few very fine roots; few very fine vesicular pores; about 55 percent gravels.

2Ckm-- 30-33" white (10YR 8/1), pink (10YR 7/4) moist; massive; extremely hard, extremely firm; mildly alkaline (pH 7.7); effervesces violently; about 20 percent gravels.

The A horizon ranges from 5 to 13 inches in thickness and from sandy loam to loam in texture. The B horizon may or may not qualify as an argillic, is 7 to 16 inches thick, and ranges in texture from sandy loam to clay loam. The coarse fragments in the horizons above the petrocalcic range in amount from 0 to 25 percent and are dominantly gravel sized. The clay content ranges from 16 to 38 percent, the weighted average clay content in the control section is between 18 and 35 percent. Depth to lime ranges from 8 to 23 inches. The calcium carbonate equivalent ranges from 0.3 to nearly 60 percent. The 2Ckm horizon is 4 to 16 inches thick and ranges from weakly to strongly cemented. The coarse fragment content ranges from 15 to 60 percent. Only remnants of this soil remain on Henderson Hill, most of it has been used as a source for gravel.

The Petrocalcic Paleustolls are similar to the Ascalon, Satanta and Bresser soils, except that they may not have an argillic horizon and that they have an indurated calcic horizon immediately below the solum and contain more gravel.

Petrocalcic Paleustolls, 0-6% slopes (Ca).

This map unit consists of soils which have petrocalcic horizons. It occurs on old alluvial terrace remnants in the Rattlesnake and Henderson Hills and North Plants area. The slopes are convex and mostly 0 to 3 percent, but slopes up to 6 percent were included. Bresser and Ascalon soils may occur as inclusions where the petrocalcic horizon is discontinuous. This map unit is of minor extent.

3.4.6 Satanta Series

The Satanta series consists of deep, well drained soils formed in medium textured, late-Wisconsin alluvium and wind deposited materials. They occur on nearly level to undulating (0 to 10 percent slopes) old alluvial terraces and terrace escarpments. These soils are moderately extensive in the eastern half of the Arsenal.

Pedon # 1-38 is a typical profile of the Satanta sandy loam and is located 400 feet west and 950 north of the southeast corner of the northeast 1/4 of section 1, T2S, R67W.

Ap-- 0-7" brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; slightly hard, very friable; slightly acid (pH 6.4); abrupt smooth boundary; common very fine roots; common very fine pores.

Bt1-- 7-14" pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; slightly hard, very friable; neutral (pH 6.6); clear smooth boundary; few very fine pores; few thin clay films.

Bt2-- 14-23" pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; slightly hard, very friable; neutral (pH 7.1); clear smooth boundary; common fine roots; common fine pores; common moderately thick clay films.

Bk-- 23-44" very pale brown (10YR 7/3) fine sandy clay loam, brown (10YR 5/3) moist; moderate fine subangular blocky structure; slightly hard, very friable; neutral (pH 7.2); strongly effervescent; clear smooth boundary; few very fine roots; few fine pores.

Ck-- 44-60" very pale brown (10YR 7/4) sandy loam, brown (10YR 5/3) moist; single grain; loose, loose; neutral (pH 7.3); slightly effervescent; many fine pores.

The A horizon ranges from 5 to 19 inches in thickness and from loamy sand to clay loam in texture. The Bt horizon is 9 to 27 inches thick and ranges in texture in some part from sandy clay loam to silty clay loam. The clay content is commonly 30 to 32 percent, but ranges from 24 to 38 percent. Depth to lime varies from 6 to 57 inches. Depth to lime is greatest where the Satanta soils occur in complex with the Bresser soils in the southeast section of the Arsenal and where they occur in closed depressions. The calcium carbonate equivalent ranges from 0.3 to 15 percent.

The Satanta soils are similar to the Ascalon soils, except that they contain a lower proportion of sands coarser than very fine sand. The Satanta soils are similar to the Bresser soils, except that they contain a lower proportion of sands coarser than very fine sand and may have lime higher in the profile. The Satanta soils are similar to the Nunn soils, except that they have less clay in the control section.

Satanta loam, 0-1% and 1-3% slopes (SaA and SaB).

These map units consist of Satanta soils with loam surface horizons. These map units occur on old alluvial terraces with planar slopes and in concave positions on water reworked eolian plains with undulating slopes. Slope gradients of 0 to 1 and 1 to 3 percent separate the SaA and SaB map units, respectively. Weld soils were included as dissimilar inclusions in the eastern part of the Arsenal. The depth to lime is greater than typical where the Satanta soils were mapped in depressions in the southeastern portion of the survey area. These units occupy a minor proportion of the Arsenal.

Satanta loam, 3-6% and 6-10% slopes (SaC and SaD).

These map units consist of Satanta soils with loam surface horizons. They occur on old terrace escarpments with slope gradients of 3 to 6 and 6 to 10 percent. Weld soils may occur as dissimilar inclusions in the northeastern corner of the Arsenal. These units are of minor extent and are restricted to the northeastern section of the survey area.

3.4.7 Truckton Series

The Truckton series consists of deep, well drained to somewhat excessively-drained soils formed in coarse textured early Holocene eolian deposits. They occur on nearly level to undulating (0 to 10 percent slopes) old, stabilized sand dunes and sandy eolian plains. These soils are moderately extensive in the south and west sections of the Arsenal.

Pedon # 1-40 is a typical profile of the Truckton loamy sand and is located 600 feet east and 750 feet north of the southwest corner of the northwest 1/4 of section 1, T3S, R67W. The Truckton series is a member of the coarse-loamy, mixed, mesic Aridic Argiustolls.

A-- 0-6" brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; moderate medium granular structure; soft, very friable; neutral (pH 6.7); clear smooth boundary; common very fine roots; many very fine vesicular pores.

Bt1-- 6-16" brown (10YR 5/3) sandy loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky structure; soft, very friable; slightly acid (pH 6.5); clear smooth boundary; few very fine roots; many very fine vesicular pores.

Bt2-- 16-24" yellowish brown (10YR 5/4) sandy loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; soft, very friable; slightly acid (pH 6.1); clear smooth boundary; few very fine roots; many very fine vesicular pores; few thin clay films and colloidial stains and bridges.

C-- 24-60" dark yellowish brown (10YR 4/4) loamy sand moist; massive; soft, very friable; slightly acid (pH 6.5); many very fine vesicular pores.

The A horizon ranges from loamy coarse sand to sandy loam in texture and from 0 to 18 inches in thickness. The Bt horizon is 6 to 28 inches thick and ranges in texture in some part from loamy sand to sandy clay loam. The clay content is commonly 16 to 17 percent, but ranges from 13 to 21 percent. Depth to lime is normally greater than 60 inches, but it may occur below 40 inches. The calcium carbonate equivalent ranges from 0.3 to about 5 percent. The C horizon varies in texture from coarse sand to fine sandy loam. Fine textured, calcareous, buried soil horizons or alluvial layers may occur, but are uncommon. The sand fraction and soil texture tends to be coarser when this soil occurs near the crest of well defined sand dune landforms.

The Truckton soils are similar to the Bresser soils, except that they have less clay in the Bt horizon. The Truckton soils are similar to the Ascalon soils, except that they have less clay in the Bt horizon and lime occurs at greater depth.

Truckton loamy sand, 1-3% slopes (TrB).

This map unit consists of Truckton soils with loamy sand surface horizons. It occurs on sandy eolian plains and old dune fields with complex, undulating slopes of 1 to 3 percent. Minor areas with slope gradients of 0 to 1 percent were included in the map unit. Bresser and Typic Haplustoll soils are similar inclusions in this unit. The map unit is confined primarily to the southeastern Arsenal and the Henderson Hill area and is limited in extent.

Truckton loamy sand, 3-6% and 6-10% slopes (TrC and TrD).

These map units consist of Truckton soils with loamy sand surface horizons. They occur on old sand dunes and ridges with slope gradients of 3 to 6 and 6 to 10 percent. The slopes are commonly complex since they include both the convex ridgetops and concave sidelopes and toeslopes of the ridges. Surface textures may be loamy coarse sand or coarse sandy loam on ridgetop positions where the finer materials presumably have been removed by erosion. These units occupy a minor proportion of the survey area and occur primarily in the south.

3.4.8 Typic Haplustolls, fine-loamy, mixed, mesic.

The Typic Haplustolls consist of deep, well drained soils formed in coarse to medium textured, Holocene alluvium, slopewash and wind deposited materials. They occur on nearly level (0 to 3 percent slopes), concave depressions and drainages on sandy eolian plains. These soils occur primarily in the south and west sections of the Arsenal and are not extensive.

Pedon # 33 is a typical profile of a fine-loamy, mixed, mesic Typic Haplustoll and is located 700 feet south and 200 feet west of the northeast corner of the southeast 1/4 of section 26, T2S, R67W.

A1-- 0-3.5" brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; weak medium subangular blocky structure; soft, very friable; slightly acid (pH 6.4); clear smooth boundary; few very fine roots; few very fine pores.

A2-- 3.5-6" brown (10YR 5/3) loamy sand, dark brown (10YR 3/3) moist; weak coarse platy structure; soft, very friable; slightly acid (pH 6.4); abrupt smooth boundary; few very fine roots; few very fine pores.

Bw1-- 6-16" pale brown (10YR 6/3) moist sandy clay loam; moderate medium to coarse angular blocky structure; soft, very friable; neutral (pH 7.0); gradual smooth boundary; few very fine roots; few very fine pores.

Bw2-- 16-29" brown (10YR 5/3) moist sandy loam; moderate medium subangular blocky structure; soft, very friable; neutral (pH 7.0); gradual smooth boundary; few very fine roots; few very fine pores.

BC-- 29-39" yellowish brown (10YR 5/4) moist sandy loam; moderate medium subangular blocky structure; slightly hard, very friable; neutral (pH 7.0); clear smooth boundary; few very fine roots; few very fine pores.

Ck-- 39-64" light yellowish brown (10YR 6/4) sandy loam, yellowish brown (10YR 5/4) moist; moderate medium to coarse subangular blocky structure; slightly hard, very friable; moderately alkaline (pH 8.1); slightly effervescent; clear smooth boundary; few very fine roots; common very fine pores.

C-- 64-72" yellowish brown (10YR 5/4) moist sandy loam; massive; slightly hard, very friable; slightly effervescent; few very fine pores.

The A horizon ranges from 5 to 20 inches in thickness and from loamy sand to clay loam in texture. The B horizon is 7 to 32 inches thick and ranges from sandy loam to clay loam in texture. The clay content ranges from 14 to 45 percent, but the weighted average in the control section is less than 35 percent. Depth to lime ranges from 25 to 60 inches and is commonly deeper than 40 inches. The calcium carbonate equivalent ranges from 0.3 to about 15 percent. These soils generally receive run-on water, but are freely drained and not saturated for extended periods.

The Typic Haplustolls are similar to Ascalon, Satanta and Bresser soils, except that they lack argillic horizons. The Typic Haplustolls are similar to Truckton soils, except that they lack argillic horizons and contain more clay in the control section.

Typic Haplustolls sandy loam, 0-3% slopes (Th).

This map unit consists of fine-loamy, mixed, mesic Typic Haplustolls with sandy loam surface horizons. This unit occupies closed depressions and weakly developed drainages on sandy eolian plains. The slopes are concave with gradients of 0 to 3 percent. This soil occurs mostly in the southern half of the Arsenal. Bresser and Aquic Haplustoll soils may occur as inclusions. The mollic epipedons in some these soils may exceed 20 inches in thickness (cumulic intergrades) near the lowest point in the delineations. This map unit occupies a minor proportion of the survey area.

3.4.9 Weld Series

The Weld series consists of deep, well drained soils formed in medium to fine textured, late-Wisconsin alluvium and wind-deposited materials. They occur on nearly level to undulating (0 to 6 percent slopes) old alluvial terraces. These soils are extensive throughout the Arsenal.

Pedon # 12 is a typical profile of the Weld loam and is located 250 feet west and 700 feet south of the northeast corner of the southwest 1/4 of section 23, T2S, R67W. The Weld series is a member of the fine, montmorillonitic, mesic, Aridic Paleustolls.

A1-- 0-4" brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; moderate coarse platy structure; slightly hard, very friable; neutral (pH 6.6); clear smooth boundary; common very fine roots; few very fine to medium pores.

A2-- 4-12" brown (10YR 4/3) moist clay loam; moderate medium subangular and angular blocky structure; hard, friable; neutral (pH 6.9); abrupt smooth boundary; few very fine roots; common fine to medium pores.

Bt-- 12-20" brown (10YR 4/3) moist clay; strong medium prismatic structure; slightly hard, very friable; mildly alkaline (pH 7.5); abrupt smooth boundary; few fine to medium roots; few very fine pores; many moderately thick clay films.

Btk2-- 20-31" brown (10YR 5/3) clay loam, brown (10YR 4/3) moist; moderate fine prismatic structure; slightly hard, very friable; moderately alkaline (pH 8.4); slightly effervescent; gradual smooth boundary; few fine roots; common very fine pores; common thin clay films.

Ck1-- 31-57" light yellowish brown (10YR 6/4) silt loam, yellowish brown (10YR 5/4) moist; massive; slightly hard, very friable; moderately alkaline (pH 8.3); slightly effervescent; clear wavy boundary; few very fine roots; common very fine pores.

2Btb-- 57-70" dark brown (7.5YR 4/4) moist sandy clay loam; massive; slightly hard, very friable; moderately alkaline (pH 8.1); strongly effervescent; few fine to medium pores; few thin clay films.

The A horizon ranges from sandy loam to clay loam in texture and from 4 to 19 inches in thickness. Vertical soil cracks extending from the surface to less than 20 inches may occur in these soils in areas that have eroded been, deeply plowed or otherwise disturbed. The Bt horizon is 12 to 37 inches thick and ranges in texture in some part from sandy clay loam to silty clay. The clay content is commonly 40 to 45 percent, and ranges from 34 to 50 percent. Depth to lime varies from 12 to 43 inches, but may occur at or near the surface in some areas. The calcium carbonate equivalent ranges from 0.3 to about 23 percent and commonly occurs in some part of the Bt horizon. Buried soil horizons and texturally contrasting alluvial layers may occur below 40 inches. These layers are commonly calcareous, may contain small amounts of granitic and sandstone gravels and have hues of 7.5YR.

The Weld soils are similar to the Nunn soils, except that they have an abrupt textural boundary between the A and Bt horizons, and less sands coarser than very fine sand in the Bt horizon.

Weld loam, 0-1% and 1-3% slopes (WeA and WeB).

These map units consist of Weld soils with loam surface horizons. They occur on old alluvial terraces with slope gradients of 0 to 1 and 1 to 3 percent. Most of the delineations are large and occur on planar slopes in the northern portion of the Arsenal. Surface texture may be clay loam in the southwest 1/4 of section 23 and other TX production areas where the soils were deeply plowed or eroded. These clay loam surface horizons crack when dry in the summer and late fall. Platner soils were not mapped in this survey, but may occur as inclusions. Laboratory data indicated that soils originally classified as Platner did not have enough sands coarser than very fine to qualify as Platner so they were classified and mapped as Weld soils. Ascalon and Bresser soils are dissimilar inclusions in northern portion of the Arsenal. Aquic Haplustolls may occur as inclusions where the Weld is mapped near First Creek. These map units are extensive in the northern sections of the Arsenal.

3.4.10 Disturbed Lands

Disturbed lands consist of an undifferentiated group of soils, fill materials, sediments, and industrial structures. The disturbed lands designation includes a wide range of disturbances and non-soil areas. The degree of disturbance also varies, but at a minimum the disturbance must have been great enough to severely impact or remove the soil surface horizons. These disturbed areas were determined on the ground and with the aid of air photos. Much of the area mapped as disturbed lands would be considered non-soil since it does not support vegetation. Within the disturbed lands map units, where soils do occur their properties vary unpredictably and may change drastically over very short distances. Structures, parking lots, and other non-soil areas were not mapped separately because they are evident on the ground, available from other sources (e.g. USATHAMA) and would clutter the soil map.

The disturbed lands designation indicates that on-site investigations may be necessary when specific information about soil horizonation and other properties are important. The completeness of the disturbed lands mapping is limited considering the date of the air photos (Summer 1981). and the on-going remedial activities.

Three phases of disturbed lands were recognized based on soil texture of the soil series that likely occurred prior to the disturbance. The soil series that existed prior to disturbance were determined when ever possible by comparing subsurface soil features from disturbed and undisturbed soils. Most disturbed areas have less organic matter in the surface horizon and a shallower depth to lime than their undisturbed counterparts. Sedimentation and effluent basins fit the disturbed lands concept, but were mapped separately and were designated as "Basin".

Disturbed land sandy, 0-3% slopes (DLS).

This map unit consists of soil and non-soil components. The non-soil component occupies about 60 percent and the soil component about 40 percent of the area. The non-soil component includes buildings, parking lots, rail yards, storage areas, landfills and other similar structures. The soil component includes materials related in properties to the Bresser and Truckton soils. Slope gradients are predominantly 0 to 1 percent with some areas ranging up to 3 percent, Small areas will have slopes greater than 3 percent, such as old burial trenchs, borrow pit sidewalls and spill containment berms. The predominate textures are loamy sand, sandy loam and sandy clay loam, though finer textured materials may occur if buried alluvial layers were intersected or fill materials were imported and cover the original soils. Depth to lime may range from near the surface to greater than 60 inches. Highly compacted layers may occur at the surface or at depth in the profile. This map unit is extensive in the South Plants area.

Disturbed land loamy, 0-3% slopes (DLL).

This map unit consists of soil and non-soil components in approximately equal proportions. The non-soils component is similar to those of the DLS map unit. The soil component includes materials related in properties to the Satanta and Ascalon soils. Slope gradients are predominantly 0 to 1 percent with some areas ranging up to 3 percent. Small areas of steeper slopes occur. Soil textures include sandy clay loam, loam and clay loam, though both finer and coarser textured materials may occur. Lime may occur at the surface and compacted layers may be encountered in the profile. This map unit is moderately extensive in the South Plants area.

Disturbed land clayey, 0-3% slopes (DLC).

This map unit consists of soil and non-soil components. The soil component occupies about 70 percent and the non-soil component occupies about 30 percent of the area. The non-soil component is similar to those in other disturbed lands map units. The soil component includes materials related in properties to the Weld and Nunn soils. Slope gradients are mostly 0 to 1 percent with some areas ranging up to 3 percent. Small areas of slopes greater than 3 percent occur. Lime may occur at the surface and compacted layers may be encountered in the soil profile. This map unit is extensive in the North Plants, North Boundary Trench and the old toxic storage areas in section 31.

3.5 Soil Properties

3.5.1 Soil Physical Properties

Soil physical and hydrologic properties of the typical soil pedons for each major soil are presented in table 3. Soil texture was determined in the laboratory; available water holding capacity, hydraulic conductivity class and shrink/swell potential were estimated based on measured soil properties and published relationships. Appendices A and B contain references to the methods used in the laboratory and for estimating these parameters, respectively. Soil particle size data for soils other than the typical pedons are contained in appendix E.

Oven-dry bulk density was determined in the laboratory on seven (7) soil profiles (appendix D). Bulk densities for soil textures found on the Arsenal were estimated, based on data from the Arsenal and published references relating bulk density and soil texture (Israelsen and Hansen, 1962; Soil Conservation Service, 1983). The bulk density data for the sampled soils tended to be high when compared to the published ranges given for other soils, and therefore the estimated values can be considered conservatively heavy. Estimated bulk densities for use in calculations were: 1.7 g/cm^3 (105 lb/ft^3) for sandy loams and loamy sands, 1.5 g/cm^3 ($90/ft^3$) for sandy clay loams, loams, and clay loams and 1.3 g/cm^3 (80 lb/ft^3) for clays, silty clays and silty clay loams. These values for are dry soil; wet soils will weigh more per unit volume. In general, surface horizons have lower bulk densities than similarly textured subsurface horizons. Disturbed areas with compacted soils may have bulk densities ranging up to 1.7 to 2.1 g/cm^3 for fine to coarse textured soils, respectively.

TABLE 3. SOIL PHYSICAL AND HYDROLOGIC PROPERTIES

Soil Series (depth)	Soil Texture % sand	% silt	% clay	% VFS	class	Available Water Holding Capacity (in/in)	Hydraulic Conductivity (in/hr)	Shrink/ Swell Potential
Aquic Haplustoll # 46								
0-6"	43	29	28	10	CL	0.22	0.14-1.4	mod
6-11	49	27	24	13	SCL	0.17	1.4-7.0	low
11-16	34	36	30	13	CL	0.19	0.14-1.4	mod.
16-41	31	48	21	20	L	0.18	0.14-1.4	low
41-46	65	19	16	10	SL	0.14	1.4-7.0	low
Ascalon # 79								
0-7"	69	17	14	10	SL	0.14	1.4-7.0	low
7-24	53	19	28	14	SCL	0.17	0.14-1.4	low
24-44	65	15	20	9	SL	0.14	1.4-7.0	low
44-67	75	11	14	11	SL	0.12	1.4-7.0	low
Bresser # 1-41								
0-8"	78	15	12	2	SL	0.13	1.4 -7.0	low
8-24	68	15	18	6	SCL	0.14	0.14-1.4	low
24-46	73	13	14	9	SL	0.12	1.4-7.0	low
46-50	69	19	12	9	SL	0.11	1.4-7.0	low
50-60	78	16	6	10	LS	0.09	1.4-14.0	low

TABLE 3. SOIL PHYSICAL AND HYDROLOGIC PROPERTIES (cont.)

Soil Series (Depth)	Soil Texture % sand	% silt	% clay	% VFS	class	Available Water Holding Capacity (in/in)	Hydraulic Conductivity (in/hr)	Shrink/ Swell Potential
Nunn # 17								
0-8"	20	44	36	17	CL	0.24	0.14-1.4	mod.
8-14	16	46	38	14	SICL	0.21	0.01-0.14	mod.
14-27	26	38	36	19	CL	0.21	0.01-0.14	mod.
27-33	38	26	36	12	CL	0.21	0.01-0.14	mod.
33-47	35	25	40	10	C	0.23	0.01-0.14	high
47-69	36	20	44	7	C	0.23	0.001-0.01	high
Petrocalcic Paleustoll # 36-32								
0-7"	67	15	18	7	SL	0.15	1.4-7.0	low
7-23	73	19	8	12	SL	0.10	1.4-7.0	low
23-33	51	43	6	6	SL	0.09	1.4-7.0	low
33+	ND	ND	ND	ND	ND	NA	< 0.001	low
Satanta # 1-38								
0-7"	38	44	18	17	L	0.20	0.14-1.4	low
7-14	34	36	30	12	CL	0.19	0.14-1.4	mod.
14-23	34	39	27	22	CL	0.19	0.14-1.4	mod.
23-44	40	43	17	18	L	0.16	0.14-1.4	low
44-60	79	14	7	7	LS	0.09	1.4-14.0	low

TABLE 3. SOIL PHYSICAL AND HYDROLOGIC PROPERTIES (cont.)

Soil Series (depth)	Soil Texture					Available Water Holding Capacity (in/in)	Hydraulic Conductivity (in/hr)	Shrink/ Swell Potential
	% sand	% silt	% clay	% VFS	class			
Truckton # 1-40								
0-6"	78	12	10	2	SL	0.12	1.4-7.0	low
6-16	76	10	14	4	SL	0.10	1.4-7.0	low
16-24	76	8	16	<1	SL	0.10	1.4-7.0	low
24-60	80	10	10	6	LS	0.09	1.4-14.0	
Typic Haplustolls # 33								
0-6"	56	20	24	12	SCL	0.16	1.4-7.0	low
6-16	59	17	24	8	SCL	0.14	1.4-7.0	low
16-29	61	15	24	3	SCL	0.14	1.4-7.0	low
29-39	65	13	22	8	SCL	0.14	1.4-7.0	low
39-60	63	13	24	7	SCL	0.14	1.4-7.0	low
Weld # 11								
0-4"	47	26	27	18	L	0.22	1.4-7.0	mod.
4-12	43	29	28	19	CL	0.19	0.14-1.4	mod.
12-20	21	29	50	17	C	0.23	0.001-0.01	high
20-31	24	42	34	17	CL	0.21	0.01-0.14	mod.
31-57	24	46	30	17	CL	0.19	0.01-0.14	mod.
57-70	47	17	36	12	SC	0.18	0.01-0.14	mod.

ND - no data NA - not applicable

3.5.2 Soil Chemical Properties

Soil chemical properties for the typical pedon of each major soil are presented in table 4. The data contained in this table were generated in the laboratory using standard methods. Appendix A contains references to the methods used in the laboratory. Appendix E contains chemical and physical data for 20 additional soils collected during this investigation. Selected chemical properties for all the soils tested are discussed below.

The soils were slightly acid to moderately alkaline. The saturated soil paste pH ranged from 6.3 to 9.0. Soil pH was lowest at the soil surface and increased with depth, though not always regularly. The high pH values (pH 8.4 to 9.0) measured in a few samples, were not associated with high levels of exchangeable sodium or high sodium absorption ratios (SAR). The specific ion(s) responsible for these relatively high pH values was not identified.

Almost all the soils were non-saline, except for a few poorly drained soils. The electrical conductivity (EC) of the saturated soil paste extract varied from 0.3 to 8.6 mmhos/cm, with most values in the 0.5 to 1.5 mmhos/cm range. These data showed no particular trend with depth, but the highest values did occur in subsurface horizons. The soils with the highest EC were in areas influenced by irrigation or drainage waters. Gypsum ($CaSO_4$) may contribute to this high EC since gypsum crystals were observed in these soils and others in similar positions.

The cation exchange capacity (CEC) varies with the type and amount of clay and organic matter. The CEC ranged from 1.6 to 39.1 meq/100g, with most soils between 10 and 25 meq\100g. The Truckton soils had the lowest CEC and the Weld and Nunn soils had the highest values. The soils with argillic horizons had the largest CEC in their Bt horizons. The highest CEC values for soils without argillics occurred in the A or B horizons.

Calcium and magnesium dominated the exchange complex of the soils tested with potassium and sodium occurring in lesser amounts. The base saturation varied from near 70 to slightly over 100 percent. These data were considered normal for soils containing free calcium carbonate.

The calcium carbonate equivalent (lime) ranged from near 0 to 60 percent. The lime in most soils increased with depth, and many soils had horizons where the lime content was greater than either the horizon above or below. The highest amounts of lime occurred in the cemented alluvial gravels of the Petrocalcic Paleustolls and in the buried soil horizons which occur in other soils. Excluding these high concentrations, most soil horizons contained much less than 10 percent lime with accumulations ranging up to 20 percent.

Most of the soils tested had between 0.6 and 2.0 percent organic carbon (O.C.) in their surface horizons. The organic carbon content of the subsurface horizons ranged from less than 0.1 to about 2 percent. The highest values occurred in the surface A horizons. The organic carbon content in most soils decreased regularly with depth within the limits of detection and excluding the influence of calcium carbonate on the laboratory test.

The soils were almost all non-sodic. The sodium absorption ratio (SAR) was low (<5) in almost all soils, and ranged from less than 1 to about 15. SAR values of 10 to 13 are generally considered to be levels of concern for sensitive plants. The single high value over 13 was in a soil (Aquic Haplustoll) with less than adequate drainage where soluble salts would be expected to accumulate.

TABLE 4. SOIL CHEMICAL PROPERTIES

Soil Series (depth)	pH	EC (mmhos/cm)	Exchangeable Bases Ca	Mg (meq/100g)	Na	K	CEC (meq/100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR
Aquic Haplustoll # 46											
0-6"	7.3	1.5	17.3	6.1	0.1	3.0	26.5	100.0	2.6	1.5	0.9
6-11	7.8	1.0	13.0	5.1	<.1	1.9	19.9	100.5	2.5	0.5	0.8
11-16	7.9	1.1	15.0	7.4	0.2	1.8	24.4	100.0	2.4	0.5	1.8
16-41	8.1	3.7	7.7	7.7	1.3	0.5	17.2	100.0	2.8	0.4	14.8
41-46	8.4	1.4	6.3	5.9	0.3	0.2	12.6	100.8	1.9	0.2	3.6
Ascalon # 79											
0-7"	6.7	0.4	7.8	3.0	0.1	0.9	12.9	91.0	0.2	0.6	2.1
7-24	7.4	0.5	15.0	6.9	<.1	0.7	22.6	100.0	0.5	0.4	0.2
24-44	8.5	0.8	10.8	4.6	0.1	0.2	15.6	100.0	2.7	0.2	1.0
44-67	8.6	0.7	7.8	2.9	0.1	0.1	10.9	100.0	1.1	0.1	2.5
Bresser # 1-41											
0-8"	6.7	1.3	7.9	1.9	0.2	0.7	11.8	90.7	0.8	0.7	2.8
8-24	7.1	0.6	13.2	4.1	0.1	0.5	17.9	100.0	0.8	0.4	2.0
24-46	7.5	0.8	8.1	2.8	0.1	0.2	11.1	100.9	1.6	0.1	1.7
46-50	7.6	1.3	6.8	2.7	0.1	0.1	9.6	100.0	9.9	0.2	2.0
50-60	7.5	2.6	3.1	2.1	0.1	0.1	5.3	100.0	12.9	0.2	4.0

TABLE 4. SOIL CHEMICAL PROPERTIES (cont.)

Soil Series (depth)	pH	EC (mmhos/cm)	Exchangeable Bases Ca	Mg (meq/100g)	Na	K	CEC (meq/100g)	Base Sat (%)	Lime (%)	O.C. (%)	SAR
Nunn # 17											
0-8"	7.2	1.1	17.4	10.8	0.1	2.8	31.0	100.0	2.4	1.1	0.8
8-14	7.7	1.0	20.9	9.0	0.1	0.5	30.5	100.0	7.5	0.5	1.2
14-27	8.2	0.8	17.5	10.6	0.1	0.4	28.3	100.0	14.6	0.3	1.0
27-33	8.3	0.7	15.3	11.8	0.4	0.4	28.0	99.0	14.9	0.3	1.3
33-47	8.4	0.8	14.5	15.9	0.2	0.4	31.0	100.0	28.3	0.3	1.8
47-69	8.4	0.8	14.0	19.3	0.1	0.5	33.9	100.0	29.3	0.2	1.4
Petrocalcic Paleustoll # 36-32											
0-7"	7.6	0.8	13.6	1.6	<.1	1.1	16.3	100.0	1.8	0.7	1.1
7-23	7.7	1.2	7.1	0.7	<.1	0.2	8.0	100.0	2.1	0.6	1.4
23-33	7.7	1.4	6.9	0.7	0.1	0.1	7.7	101.3	59.4	0.8	1.8
33+			calcium carbonate cemented horizon								
Satanta # 1-38											
0-7"	6.4	0.8	8.0	4.4	0.1	1.7	17.9	79.3	0.8	1.2	2.2
7-14	6.6	1.2	10.7	8.7	0.9	1.6	25.1	87.3	1.0	0.7	6.3
4-23	7.1	4.8	9.2	10.9	1.2	0.8	22.1	100.0	1.1	0.5	8.3
3-44	7.2	4.7	7.8	4.8	0.9	0.3	13.8	100.0	17.3	0.3	11.1
44-60	7.3	8.6	3.9	1.4	0.3	0.1	5.7	100.0	3.3	0.1	7.6

TABLE 4. SOIL CHEMICAL PROPERTIES (cont.)

Soil Series (depth)	pH	EC (mmhos/cm)	Exchangeable Bases (meq/100g) Ca	Mg	Na	K	CEC (meq/100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR
Truckton # 1-40											
0-6"	6.7	0.7	5.9	1.9	0.3	0.8	10.1	88.1	0.3	0.7	2.1
6-16	6.5	0.6	6.9	2.3	0.1	0.7	11.9	84.0	0.3	0.4	2.1
16-24	6.1	0.6	6.6	2.3	0.1	0.4	13.2	71.2	0.3	0.3	1.3
24-60	6.5	0.6	4.7	1.6	<.1	0.2	7.9	82.3	0.4	0.1	1.7
Typic Haplustoll # 33											
0-6"	6.4	0.7	11.5	2.5	0.1	1.6	19.3	81.3	1.5	0.4	1.0
6-16	7.0	0.6	13.1	4.6	0.1	0.8	18.7	99.5	1.5	0.2	1.0
16-29	7.0	0.6	13.1	5.0	<.1	0.5	18.6	100.0	1.8	0.2	0.7
29-39	7.0	0.5	11.3	5.2	<.1	0.5	17.0	100.0	1.8	0.1	1.2
39-60	8.1	0.8	13.3	4.5	<.1	0.4	18.3	99.5	6.9	0.1	0.8
Weld # 11											
0-4"	6.6	0.6	12.2	7.2	0.1	3.6	26.7	86.0	0.4	1.7	1.5
14-12	6.9	0.4	12.9	8.2	<.1	1.5	23.2	97.0	0.3	0.6	0.4
2-20	7.5	0.7	21.8	15.7	0.4	1.2	39.1	100.0	0.7	0.4	1.3
20-31	8.4	0.9	17.4	9.7	0.2	0.4	27.7	100.0	6.0	0.3	1.8
31-57	8.3	1.1	15.2	7.3	0.2	0.4	23.1	100.0	5.9	0.2	2.4
57-70	8.1	1.1	18.1	8.6	0.3	0.5	27.5	100.0	3.3	0.2	1.7

3.5.3 Soil Mineralogical Properties

The clay fraction (< 0.002 mm) of 37 soil samples from eight pedons was analyzed using x-ray diffraction. Analysis and interpretation of the x-ray diffraction patterns was performed by the Institute for Arctic and Alpine Research, University of Colorado, Boulder. The results listed by soil series, and the method used in the interpretation of the x-ray diffraction patterns are given in Appendix C. These data are summarized below.

The dominant clay minerals were smectites, micas and kaolinite. A few horizons contained trace amounts of chlorite and mixed-layer mica/smectite. Most samples contained clay sized quartz, feldspars, calcite and dolomite.

Kaolinite occurred in moderate abundance in all samples tested, regardless of soil type or depth. Smectite was more abundant in soils with argillic horizons (Argiustolls) than those soils without argillic horizons (Haplustolls). Smectite was generally absent or present in trace amounts in most surface samples, and increased in abundance in the B and Bt horizons. Micas occurred in all soils and generally decreased in abundance with depth in the soils with argillic horizons. In soils lacking argillic horizons the relative abundance of micas remained constant or increased with depth.

3.6 Map Unit Interpretations

Map unit interpretations were made for each map unit based on soil and landscape properties. The properties of the most limiting or dominant soil in the map unit were used in making the interpretations. The surface soil was assumed to be missing in the disturbed lands map units, so subsoil properties of the dominant or most limiting soil were used in making the interpretations for these map units. The map units were assessed in terms of their hydrologic properties and erosion and revegetation potential. The map units are listed in table 5, the map unit interpretations are contained in tables 6 and 7.

The interpretations were made using guidelines from published sources and the information obtained in the field and from the laboratory during the execution of the soil survey. The methods for making these interpretations are referenced in appendix B.

Table 5. List of Map Units.

Map Unit Symbol	Map Unit Name
AsA	Ascalon sandy loam, 0-1% slopes
AsB	Ascalon sandy loam, 1-3% slopes
AsC	Ascalon sandy loam, 3-6% slopes
AsD	Ascalon sandy loam, 6-10% slopes
BrA	Bresser sandy loam, 0-1% slopes
BrB	Bresser sandy loam, 1-3% slopes
BrC	Bresser sandy loam, 3-6% slopes
BrD	Bresser sandy loam, 6-10% slopes
BsA	Bresser-Satanta sandy loam complex, 0-1% slopes
BsB	Bresser-Satanta sandy loam complex, 1-3% slopes
Ca	Petrocalcic Paleustolls, 1-3% slopes
Fa	Aquic Haplustolls, sandy loam-loam, 0-3% slopes
NuA	Nunn clay loam, 0-1% slopes
NuB	Nunn clay loam, 1-3% slopes
SaA	Satanta loam, 0-1% slopes
SaB	Satanta loam, 1-3% slopes
SaC	Satanta loam, 3-6% slopes
SaD	Satanta loam, 6-10% slopes
TrB	Truckton loamy sand, 1-3% slopes
TrC	Truckton loamy sand, 3-6% slopes
TrD	Truckton loamy sand, 6-10% slopes
Th	Typic Haplustolls, sandy loam, 0-3% slopes
WeA	Weld loam, 0-1% slopes
WeB	Weld loam, 1-3% slopes
DLS	Disturbed land sandy, 0 to 3 % slopes
DLL	Disturbed land loamy, 0 to 3 % slopes
DLC	Disturbed land clayey 0 to 3 % slopes

TABLE 6. MAP UNIT HYDROLOGIC INTERPRETATIONS

Map Unit Symbol	Hydrologic Group	AWHC Class	Permeability (in\hr)	Surf. Runoff	Depth (inches) to Ground water	Depth (inches) to Restrictive layer
AsA	B	moderate	0.6-2.0	v. slow	>60	>60
AsB	B	moderate	0.6-2.0	slow	>60	>60
AsC	B	moderate	0.6-2.0	slow	>60	>60
AsD	B	moderate	0.6-2.0	medium	>60	>60
BrA	B	moderate	0.6-2.0	v. slow	>60	>60
BrB	B	moderate	0.6-2.0	slow	>60	>60
BrC	B	moderate	0.6-2.0	slow	>60	>60
BrD	B	moderate	0.6-2.0	medium	>60	>60
BsA	B	moderate	0.6-2.0	v. slow	>60	>60
BsB	B	moderate	0.6-2.0	slow	>60	>60
Ca	C	low	<0.06	slow	>60	20-40
Fa	C	high	0.6-2.0	v. slow	12-40	>60
NuA	C	v. high	0.06-0.2	v. slow	>60	>60

TABLE 6. MAP UNIT HYDROLOGIC INTERPRETATIONS (cont.)

Map Unit Symbol	Hydrologic Group	AWHC Class	Permeability Class	Surf. Runoff	Depth (inches) to Ground water	Depth (inches) to Restrictive layer
NuB	C	v. high	0.06-0.2	low	>60	>60
SaA	B	high	0.6-2.0	v. slow	>60	>60
SaB	B	high	0.6-2.0	slow	>60	>60
SaC	B	high	0.6-2.0	slow	>60	>60
SaD	B	high	0.6-2.0	medium	>60	>60
TrB	B	low.	2.0-6.0	slow	>60	>60
TrC	B	low	2.0-6.0	slow	>60	>60
TrD	B	low	2.0-6.0	slow	>60	>60
Th	B	high	0.6-2.0	v. slow	>60	>60
WeA	C	v. high	0.06-0.2	slow	>60	>60
WeB	C	v. high	0.06-0.2	slow	>60	>60
DLS	B	moderate	0.6-2.0	slow	>60	>60
DLL	B	high	0.6-2.0	slow	>60	>60
DLC	C	high	0.06-0.2	slow	>60	>60

TABLE 7. MAP UNIT EROSION AND REVEGETATION INTERPRETATIONS

Map Unit Symbol	Soil Erodibility Index		K Factor		Reveg. Potential	Sources of		Frost Potential
	water(KLS)	wind(I)	surf.	subsurf.		topsoil	sand	
AsA	3	90	.17	.20	moderate	fair	poor	moderate
AsB	6	90	.17	.20	moderate	fair	poor	moderate
AsC	11	90	.17	.20	moderate	fair	poor	moderate
AsD	24	90	.17	.20	low	fair	poor	moderate
BrA	2	90	.10	.12	moderate	fair	fair	moderate
BrB	4	90	.10	.12	moderate	fair	fair	moderate
BrC	7	90	.10	.12	moderate	fair	fair	moderate
BrD	14	90	.10	.12	moderate	fair	fair	moderate
BsA	2	90	.15	.17	high	good	fair	moderate
BsB	5	90	.15	.17	high	good	fair	moderate
Ca	3	90	.12	.24	low	poor	poor	moderate
Fa	8	60	.20	.21	high	good	poor	high
NuA	5	50	.32	.35	moderate	poor	poor	low
NuB	9	50	.32	.35	moderate	poor	poor	low

TABLE 7. MAP UNIT EROSION AND REVEGETATION INTERPRETATIONS (cont.)

Map Unit Symbol	Soil Erodibility Index		K Factor		Reveg. Potential	Sources of		Frost Potential
	water(KLS)	wind(I)	surf.	subsurf.		topsoil	sand	
SaA	5	50	.32	.35	moderate	good	poor	moderate
SaB	11	50	.32	.35	moderate	good	poor	moderate
SaC	21	50	.32	.35	moderate	good	poor	moderate
SaD	45	50	.32	.35	moderate	good	poor	moderate
TrB	3	135	.10	.12	moderate	poor	fair	moderate
TrC	7	135	.10	.12	moderate	poor	fair	moderate
TrD	14	135	.10	.12	moderate	poor	fair	moderate
Th	4	90	.15	.17	high	good	poor	high
WeA	4	50	.28	.30	moderate	poor	poor	low
WeB	10	50	.28	.30	moderate	poor	poor	low
DLS	4	135	.12	.12	low	poor	poor	moderate
DLL	7	90	.20	.20	low	poor	poor	moderate
DLC	12	60	.35	.35	low	poor	poor	low

Note: Revegetation potential is usually 1 class lower if surface horizon is removed

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5.0 GLOSSARY

alluvium - Sediment deposited by a stream or running water.

aquic - A mostly reducing soil moisture regime nearly free of dissolved oxygen due to saturation by ground water or its capillary fringe and occurring at periods when the soil temperature at 50 cm is above 5 C. See Soil Taxonomy.

argillic horizon - A mineral soil horizon that is characterized by the illuvial accumulation of layer-lattice silicate clays. See Soil Taxonomy.

aridic - A soil moisture regime that has no moisture available for plants for more than half the cumulative time that the soil temperature at 50 cm is above 5 C and has no period as long as 90 consecutive days when there is moisture for plants while the soil temperature at 50 cm is continuously above 8 C. See Soil Taxonomy.

association, soil - (i) A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, (ii) A mapping unit used on general soil maps, in which two or more defined taxonomic units occurring together in a characteristic pattern are combined because the scale of the map or the purpose for which it is being made does not require delineation of the individual soils.

bulk density, soil - The mass of dry soil per unit volume. The bulk volume is determined before drying to constant weight at 105 C.

calcareous - Soil containing sufficient free calcium carbonate or magnesium carbonate to effervesce visibly when treated with cold hydrochloric acid.

cation-exchange capacity (CEC) - The sum total of exchangeable cations that a soil can absorb. Expressed in meq/100 g.

classification, soil - The systematic arrangement of soils into groups or categories on the basis of their characteristics. USDA soil classification system (Soil Taxonomy) was adopted for use in publications by the National Cooperative Soil Survey.

clay - (i) A soil separate consisting of particles < 0.002 mm in equivalent diameter. (ii) A textural class; 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

clay films - Coatings of clay on the surfaces of soil peds and mineral grains and in soil pores. (Also called clay skins, clay flows, illuviation cutans, argillans.)

coarse fragments - Rock or mineral particles >2.0 mm in diameter.

compaction - Increasing soil bulk density and decreasing porosity due to the application of mechanical forces to the soil.

complex - A mapping unit used in detailed soil surveys where two or more soils are intermixed geographically in a known way but are not mapped separately to avoid complicating the map.

consociation - A soil map unit dominated by one soil type.

cumulic - A subgroup with thick mollic epipedon (> 20 in), of an organic matter content decreasing irregularly with depth or remaining high at depth. See Soil Taxonomy.

depth, soil - The terms and their meanings used to describe depth of the soil over bedrock or over a restricting layer are: <u>deep</u>, more than 40 inches; <u>moderately deep</u>, 20 to 40 inches.

drainage, natural - The relative rapidity and extent of the removal of water from on and within the soil under natural conditions. Terms commonly used to describe drainage are:

Excessively drained - Water is removed from the soil rapidly. The soils are typically sandy and porous.

Well drained - Water is removed from the soil readily but not rapidly. There is no evidence of wetness above a depth of 40 inches.

Moderately well drained - Water is removed from the soil somewhat slowly so that the soil is wet for short, but significant, periods of time.

Somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods but not all the time. Wetness is apparent between a depth of 20 and 40 inches.

Poorly drained - Water is removed from the soil so slowly that the water table is at or on the surface most of the time. Wetness is apparent within 20 inches of the surface.

Very poorly drained - Water is removed from the soil so slowly that the water table is at or on the surface most of the time. These soils are generally in low areas or depressions.

EC - The electrical conductivity of an extract from a saturated soil paste, normally expressed in units of mmhos/cm at 25 C.

floodplain - Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

horizon, soil - A layer of soil, approximately parallel to the ground surface, that has distinct characteristics produced by soil forming processes.

hydrologic soil groups - The hydrologic soil groups are used to estimate runoff from rainfall. Soil properties which are considered are those that influence the rate of infiltration obtained from a bare soil after prolonged wetting. Soil properties considered are: (1) depth of seasonally high water table, (2) intake rate and permeability after prolonged wetting, (3) depth to very slowly permeable layer. The soils have been classified into four groups, A through D. Group A soils have low runoff potential; group B soils have moderately low runoff potential; Group C soils have moderately high runoff potential; and Group D soils have high runoff potential.

mesic - A soil temperature regime that has a mean annual soil temperature of 8 C to 15 C, with more than 5 C difference between the mean summer and mean winter soil temperatures measured at 50 cm.

miscellaneous landtype - A mapping unit for areas of land that have little or no natural soil. Includes: badland, mine land, river wash, rough broken land, rubble land, scoria land, slickens, stony land, swamp, urban land, and disturbed land.

mollic epipedon - A surface horizon of mineral soil that is enriched with organic matter, dark colored, relatively thick and has a relatively high base status.

particle size - The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

pedon - A three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations. Its area ranges from 1 to 10 square meters. When horizons are intermittent or cyclic, and recur at linear intervals of 2 to 7 m, the pedon includes one-half of the cycle. Where the cycle is less than 2 m, or all horizons are continuous and of uniform thickness, the pedon has an area of approximately 1 square meter. If the horizons are cyclic, but recur at intervals greater than 7 m, the pedon reverts to the 1 square meter size, and more than one soil will usually be represented in each cycle.

permeability, soil - That quality of the soil that enables it to transmit water or air.

pH, soil - The negative logarithm of the hydrogen-ion activity of a saturated soil paste.

phase, soil - A subdivision of a soil type or other unit of classification having characteristics that affect the use and management of the soil. A variation in a property or characteristic such as surface texture, degree of slope, degree of erosion, content of stones, etc.

profile, soil - A vertical section of the soil through all its horizons.

sand - A soil particle between 0.05 and 2.0 mm in diameter; A soil textural class.

silt - (i) A soil separate consisting of particles between 0.05 and 0.002 mm in equivalent diameter. (ii) A soil textural class.

slope, soil - In this report, slope is expressed in general descriptive terms. Each term refers to the range of slope expressed in percent (number of feet of vertical rise or fall in 100 feet horizontal distance). Slope terms are given for both single and complex slopes as follows:

Simple Slopes	Complex Slopes	Percent Slope
Nearly flat		Less than 1 percent
Nearly level	Gently undulating	1 to 3 percent
Gently sloping	Undulating	3 to 8 percent
Sloping	Gently rolling	8 to 15 percent
Moderately steep	Rolling	15 to 30 percent
Steep		30 to 45 percent
Very steep		45 percent plus

sodium adsorption ratio (SAR) - The ratio of soluble sodium to soluble calcium and magnesium which can be used to predict the sodium hazard. It is defined as follows:

$$SAR = Na/(Ca + Mg/2)^{1/2}$$

Where, Na, Ca and Mg are expressed in meq/l.

soil formation factors - The variable, usually interrelated natural agencies that are active in and responsible for the formation of soil. The factors are usually grouped into five major categories as follows: parent rock, climate, organisms, topography, and time.

soil map - A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface.

soil series - The basic unit of soil classification being a subdivision of a family and consisting of soils which are essentially alike in all major profile characteristics except the texture of the A horizon.

subsoil - The soil below the surface soil and above the substratum. It includes the B horizon and other horizons in the equivalent vertical position.

surface soil - The uppermost part of the soil, usually the A of Ap horizon.

undifferentiated group - Soil mapping units in which two or more similar taxonomic soil units occur, but not in a regular geographic association. For example, the steep phases of two or more similar soils might be shown as a unit on a map because topography dominates the properties. See soil association and soil complex.

ustic - A soil moisture regime that is intermediate between the aridic and udic regimes. A limited amount of moisture is available for plants but occurs at times when the soil temperature is optimum for plant growth.

Water table - The upper surface of ground water or that level in the ground where the water is at atmospheric pressure.

6.0 APPENDICES

6.1 Appendix A. Laboratory Methods.

Parameter	Source
Saturated Paste pH	ASA # 9-2, section 12-2
Electrical Conductivity of Saturation Extract (EC)	ASA # 9-2, section 10-3
Calcium Carbonate Equivalent Percent (Lime)	USDA Handbook # 60, Method 27a
Exchangeable Cations (Ca, Mg Na, K)	ASA # 9-2, section 9-2
Cation Exchange Capacity (CEC)	ASA # 9-2, section 8-3
Base Saturation Percent	ASA # 9-2, section 9-2, section 8-3
Sodium Absorption Ratio (SAR)	USDA Handbook # 60 Method 20b
Organic Carbon (O.C.)	ASA # 9-2, section 29-4
Particle Size Analysis	ASA # 9-1, section 43.5
Bulk Density	ASA # 9-1, section 30-2

ASA # 9-1 (Black et al, 1965).

ASA # 9-2 (Page et al, 1982.)

USDA Handbook # 60 (Salinity Laboratory Staff, 1954.)

See Section 4.0 in main document for full citations.

6.2 Appendix B. Interpretation Methods.

Interpretation	Source
Soil Erodibility/Water	Universal Soil Loss Equation KLS factors multiplied by 10 to remove decimal numbers. SCS Colorado Erosion Handbook and Agric. Handbook No. 537.
Soil Erodibility/Wind	Wind erosion I factor from the SCS Colorado Erosion Handbook.
K Factors	Agricultural Handbook No. 537
Hydrologic Groups	NSHB Part 603.02-2(f)
Frost Potential	NSHB Part 603.02-2(g)
Surface Runoff	Soil Survey Manual, Ch. 4-34
Available Water Holding Capacity	Table 7.4, Israelsen and Hanson (1962)
Hydraulic Conductivity	NSHB Part 603.02-1(h)
Permeability Class	NSHB Part 603.02-1(h)
Shrink/Swell Potential	NSHB Part 603.02-1(l)
Revegetation Potential	USDA-FS, R3, Soil Manual, Section 2550-13, 1980.
Source of Topsoil	NSHB Part 603.03-3(d)
Source of Sand	NSHB Part 603.03-3(b)
Frost Potential	NSHB Part 603.02-2(g)

NSHB (Soil Conservation Service, 1983).

Agric. Handbook # 537 (Wischmeier and Smith, 1978).

Colorado Erosion Handbook (Soil Conservation Service, 1988).

Soil Survey Manual (Soil Survey Staff, 1983).

USDA-FS (Soil Staff, 1980).

See section 4.0 in main document for full citations.

6.3 Appendix C. Clay Mineralogy.

Clay Mineralogical Methods and Interpretation

by

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SUMMARY

Detailed x-ray diffraction analyses of the <2 micron grain-size fraction from 8 soil profiles demonstrate that the principal clay minerals are, in varying proportions, smectite, mica and kaolinite (Table 1). Chlorite is also present in trace amounts in three samples and mixed layer mica/smectite, which consists of roughly 80% non-expandable mica, occurs in one sample. In general, the proportion of smectite increases downward in the soil profiles, whereas that of mica decreases. Moreover, the decrease in mica content is typically associated with a decrease in sharpness of the 001 mica peak, suggesting that the crystallinity of the mica also decreases downward, with decreasing abundance.

METHODS

Thirty-seven samples from eight soil profiles were subjected to detailed x-ray diffraction analyses of the <2 micron grain-size fraction. In preparation for the analysis, clay-coated, air-dried tiles were prepared by Dr. Rolf Kihl of the Sedimentology Laboratory, Institute of Arctic and Alpine Research, University of Colorado. (Questions concerning pre-treatment of the sediments should be directed to Dr. Kihl.) The x-ray diffraction analyses were conducted on a Rigaku diffractometer set at a scan rate of 2 degrees per minute. After an initial x-ray scan, all of the tiles were subjected to the following treatments, in progression: glycolation, heating at 300, and again, at 550°C. Following each treatment step, all tiles were rescanned. After identification of the various clay minerals by comparison of the character of all four x-ray traces (air-dried, glycolated, 300°C, and 550°C), the relative abundance of each mineral was assessed by the modified method (Shroba, 1977) of Birkeland and Janda (1971).

INTERPRETATION OF X-RAY PATTERNS

Identification of the clay-sized minerals involved comparison of the x-ray patterns of untreated and treated tiles with x-ray diffraction patterns of known, standard minerals (Brindley and Brown, 1980; Reynolds and Hower, 1979; Hower, 1981). On the air-dried trace, smectite characteristically displays a broad peak of the 001 basal reflection between 4 and 7^{o} 2θ. After glycolation, the 001 peak becomes sharper and shifts to 5.2^{o} 2θ. Higher-order basal reflections of pure smectite include those at 10.4 and 15.5^{o} 2θ; these peaks, however, are generally of very low intensity and difficult to identify in all cases (see the x-ray trace of glycolated sample 5574). Heat treatment of a sample containing smectite above $300^{o}C$ results in collapse of the 5.2^{o} 2θ peak to one at 8.8^{o} 2θ.

Mica possesses two distinctive peaks--the 001 basal reflection at $8.^{8o}$ 2θ and the 002 reflection at 17.7^{o} 2θ. These reflections are unaffected by glycolation and heat treatments. Mixed-layer mica/smectite is distinguished by both the presence of a broad peak between 4 and 7^{o} 2θ and by two higher-order peaks that occur between 10.4 and 8.8^{o} 2θ and 15.7 to 17.7^{o} 2θ.

Kaolinite, on an air-dried tile, typically displays two basal reflections at 12.4^{o} and 24.8^{o} 2θ, corresponding to the 001 and 002 basal reflections, respectively. Chlorite, however, possesses three basal reflections, at 6.2, 12.6, and 25.2^{o} 2θ; all three peaks generally overlap those of smectite and kaolinite. The x-ray trace after heating of the tile to $550^{o}C$ enables identification of chlorite in samples that contain both smectite and kaolinite. During heating, the 5.2^{o} 2θ smectite peak collapses (disappears) and the 6.2^{o} 2θ peak increases in intensity.

Other minerals present include: quartz, feldspars, calcite and dolomite. The 2θ angles, in degrees, for these minerals are listed below:

MINERAL	2θ ANGLES
Quartz	20.8, 26.6, 36.6
Feldspar	between 27.0 and 28.0
Calcite	between 29.4 and 30.3
Dolomite	between 30.8 and 31.0

RESULTS

X-ray diffraction analyses reveal that the primary clay minerals are smectite, mica, and kaolinite. Also present in some samples are trace amounts of chlorite and mixed-layer mica/smectite. Other minerals that are present in the samples include quartz, feldspars, calcite, and dolomite. The results are listed in Table 1 and a brief discussion is given below.

Six of the eight profiles (including NRS 2313, 1-40, 1-41, 1-38, 1-39, and 36-17) display an increase in the proportion of smectite and a corresponding decrease in mica downward in the soil profile. Associated with the decrease in mica content is a progressive deterioration of the sharpness of the 8.8 2θ mica peak. Shroba (1977) concluded that the variation in sharpness of this peak was an indication of the degree of crystallinity of the mica. To display the variation in mica crystallinity within a soil profile, he proposed six crystallinity stages corresponding to the progressive decrease in sharpness of the 8.8 peak, after glycolation. Following Shroba's scheme, there appears to be a progressive decrease in crystallinity of the mica in the soil profiles of this study, in conjunction with the downward decrease in the proportion of mica (see profile 1-41).

In most of the profiles, the proportion of kaolinite is relatively constant throughout, except in profile 1-41 in which there is a pronounced decrease in kaolinite content with depth.

Because chlorite and mixed-layer mica/smectite are present in only trace amounts in a few samples, meaningful trends could not be discerned.

REFERENCES

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Brindley, G. W. and G. Brown. 1980. Crystal structures of clay minerals and their x-ray identification. Mineralogical Society, Great Britain, 495 p.

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Reynolds, R. C. and J. Hower. 1970. The nature of interlayering of mixed-layer illite-montmorillonite. Clays and Clay Minerals, v. 18, p. 25-36.

Shroba, R. R. 1977. Soil development in Quaternary tills, rock-glacier deposits, and taluses, southern and central Rocky Mountains. Unpublished Ph.D. thesis, University of Colorado, Boulder, 424 p.

TABLE 6.3.1

RELATIVE ABUNDANCE[1] OF CLAY MINERALS

Soil Series	Lab No.	Smec[2]	Mica	Kaol[2]	Chl[2]	Mica/Smec[2]	Mica Peak[3]
Weld							
NRS 2312-0-9	5564	-	XXX	XX	-	-	SSB
9-12	5564	XXX	XX	XX	-	-	SSB
21-39	5565	XXX	X	XX	Tr	-	SB
39-58	5566	XXX	X	XX	-	-	SB
58-63	5567	XX	XX	XX	-	-	SSB
Truckton							
1-40-00-06	5569	X	XX	XX	-	Tr	SH
06-16	5570	X	XX	XX	-	-	SH
16-24	5571	XX	X	XX	-	-	SH
24-60	5572	XX	X	XX	-	-	SH
Bresser							
1-41-00-08	5573	XX	XX	XX	-	-	SH
08-24	5574	XXX	X	XX	-	-	SB
24-46	5575	XXX	X	X	-	-	SB
46-50	5576	XXX	Tr	X	-	-	VSB
50-60	5577	XX	Tr	Tr	-	-	VSB
Aquic Haplustoll							
NRS-3146-0-6	5574	-	XX	XX	-	-	SH
6-11	5575	Tr	XX	XX	-	-	SH
11-16	5576	X	XX	XX	-	-	SSB
16-41	5577	X	XX	XX	-	-	SSB
41-46	5578	Tr	XX	XX	-	-	SSB
Satanta							
1-38-00-07	5579	-	XX	XX	-	-	SH
07-14	5580	X	XX	XX	-	-	SSB
14-23	5581	XX	XX	XX	-	-	SSB
23-44	5582	XX	X	XX	Tr	-	SSB
44-60	5583	XXX	X	XX	Tr	-	SSB
Satanta							
1-39-00-06	5584	-	XXX	XX	-	-	SSB
06-19	5585	-	XXX	XX	-	-	SSB
19-44	5586	-	X	XX	-	-	SB
44-54	5587	XX	XX	XX	-	-	SSB
54-60	5588	XXX	X	XX	-	-	SSB
Aquic Haplustoll							
02-15-00-15	5589	Tr	XX	XX	-	-	SSB
15-24	5590	-	XXX	XX	-	-	SSB
24-34	5591	-	XXX	XX	-	-	SB
34-60	5592	Tr	XXX	XX	-	-	SSB

Soil Series	Lab No.	Smec[2]	Mica	Kaol[2]	Chl[2]	Mica/Smec[2]	Mica Peak[3]
Ascalon							
36-17-00-11	5593	-	XXX	XX	-	-	SSB
11-25	5594	XXX	XX	XX	-	-	SSB
25-47	5595	XXX	X	XX	-	-	SB
47-59	5596	XXX	X	XX	-	-	VSB

[1]Relative abundance denoted as follows:

Abundant	XXX	Trace Amounts	Tr
Moderate	XX	Not Detected	-
Minor	X		

[2]Clay minerals are denoted as follows: Smectite, Smec; Kaolinite, Kaol; mixed-layer Mica/Smectite, Mica/Smec.

[3]The degree of sharpness of the 8.8^{o} 2θ mica peak after glycolation; see text for discussion. Abbreviations are as follows: Very Sharp, VSH; Sharp, SH; Slightly Subdued, SSB; Subdued, SB; Very Subdued, VSB; Absent, A.

6.4 Appendix D. Soil Bulk Density.

Soil Series (depth)	Bulk Density (Mg/m^3)	Soil Texture Class
Ascalon # 30-17		
0-6"	1.39	loam
6-15	1.58	loam
15-36	1.62	sandy clay loam
36-53	0.91	clay
Satanta # 1-43 (disturbed)		
0-21"	1.70	loam
21-25	2.12	sandy loam
25-36	1.56	loam
36-47	1.61	loam
47-59	1.53	loam
Bresser # 1-46 (disturbed)		
0-17"	1.78	sandy loam
17-23	ND	sandy clay loam
23-30	2.04	sandy loam
30-46	1.38	sandy loam
46-59	1.59	sandy loam
Bresser # 2-34		
0-7"	1.55	loamy sand
7-18	1.80	sandy loam
18-25	1.74	sandy loam
25-55	1.65	loamy sand
55-61	1.71	sandy loam
Truckton # 2-37 (disturbed)		
0-4"	1.60	sandy loam
4-10	1.94	sandy loam
10-25	1.84	sandy loam
25-49	1.63	sandy loam
49-60	1.77	sandy loam
Satanta # 36-12		
0-8"	1.57	loam
8-18	1.63	clay loam
18-36	1.53	loam
36-50	1.55	loam
50-57	1.49	sandy clay loam
Ascalon # 36-17		
0-11"	1.62	sandy loam
11-25	1.61	loam
25-47	1.60	sandy loam
47-59	1.82	sandy loam

6.5 Appendix E. Soil Chemical and Physical Properties.

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	Particle Size sand (%)	silt (%)	clay (%)	VFS (%)
Aquic Haplustoll # 2-15												
0-15"	A	7.7	1.4	13.2	99.2	3.3	1.1	5.4	67	21	12	9
15-24	C1	7.7	3.2	7.4	98.7	1.2	0.3	9.7	80	12	8	2
24-34	C2	7.7	2.0	13.4	100.0	0.7	0.4	6.4	63	21	16	10
34-60	Cg	7.7	1.0	13.2	100.0	0.5	0.3	4.5	70	14	16	2
Aquic Haplustoll # 83C												
0-12"	A	6.9	0.6	12.4	96.0	0.7	0.9	2.2	54	34	12	19
12-19	AB	8.2	1.3	26.6	100.0	2.4	0.7	6.6	39	29	32	7
19-27	Ck1	8.1	2.1	26.5	100.0	9.8	0.4	7.1	33	53	14	17
27-39	Ck2	7.9	3.1	13.8	99.3	8.1	0.2	6.8	51	32	17	7
39-60	Ck3	7.6	4.7	21.1	99.5	28.1	0.2	8.5	52	21	27	6
Ascalon # 6-31												
0-7"	A	7.0	0.6	19.7	99.0	0.5	0.9	1.5	56	22	22	7
7-19	Bt	6.7	0.6	18.3	89.0	0.6	0.5	1.1	52	26	22	10
10-31	BC	7.4	1.6	8.3	100.0	0.8	0.2	1.4	67	23	10	10
31-48	Ck	8.0	1.2	12.6	100.0	5.9	0.2	1.4	66	18	16	4
48-58	C	8.1	1.4	13.9	100.0	7.2	0.3	2.0	68	14	18	4
Ascalon # 36-17												
0-11	A	7.5	0.7	10.9	99.1	0.7	0.6	1.3	58	28	14	14
11-25	Bt	7.6	1.0	18.3	100.1	1.8	0.5	1.0	49	29	22	12
25-47	Bk	8.2	0.7	11.3	99.1	7.5	0.2	1.2	69	17	14	10
47-59	Ck	8.4	0.7	10.9	100.0	6.5	0.1	1.3	73	13	14	7

Appendix E. Soil Chemical and Physical Properties (cont.).

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	sand (%)	Particle Size silt (%)	clay (%)	VFS (%)
Ascalon # 25												
0-5"	A	6.9	0.4	18.2	97.0	0.3	0.8	1.2	57	23	20	15
5-14	Bt	7.5	0.8	22.8	100 0	0.5	0.3	0.1	56	16	28	10
14-22	Btk	8.3	0.5	28.6	100.0	16.1	0.4	0.5	46	18	36	9
22-45	Ck1	8.5	0.8	23.1	100.0	21.2	0.3	1.0	57	13	30	9
45-59	Ck2	8.3	1.0	16.7	100.0	5.0	<0.1	1.7	67	11	22	14
59-67	Ck3	8.2	1.0	18.4	100.0	4.7	0.1	2.5	59	17	24	7
Bresser # 6-30												
0-9"	A	6.6	0.7	14.4	86.8	0.4	0.6	1.8	62	22	16	8
9-22	Bt	7.5	0.3	19.6	100.0	0.5	0.4	1.0	53	23	24	14
22-47	Ck	7.7	2.7	12.4	100.8	19.6	0.1	4.3	60	24	16	3
47-60	C	7.6	1.6	9.8	100.0	1.1	0.2	2.2	74	14	12	3
Bresser # 2-34												
0-7"	A	7.6	0.6	8.0	101.3	0.5	0.5	1.7	80	12	8	6
7-18	Bt1	6.9	0.4	14.9	97.3	0.6	0.4	0.9	61	21	18	7
18-25	Bt2	7.6	1.1	14.7	100.0	1.2	0.3	2.7	59	23	18	10
25-55	BC	7.1	0.3	9.6	100.0	0.3	0.2	1.1	75	13	12	9
55-61	Ck	8.1	0.7	7.9	100.0	1.1	0.1	1.0	80	10	10	4
Bresser (disturbed) # 1-46												
0-17	Fill	8.0	0.9	14.5	100.0	4.0	0.3	1.6	60	22	18	14
17-23	Ab	7.6	0.8	17.5	100.6	0.8	0.3	3.2	52	26	22	8
23-30	Btb	7.7	1.2	16.0	99.4	3.8	0.3	2.8	54	26	20	12
30-46	Ck1	8.2	0.8	10.9	100.0	6.4	0.1	2.1	69	17	14	15
46-59	Ck2	8.2	0.8	11.1	100.0	6.1	0.1	2.8	69	17	14	10

Appendix E. Soil Chemical and Physical Properties (cont.).

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	Particle Size sand (%)	silt (%)	clay (%)	VFS (%)
Bresser # 73D												
0-8"	A	6.5	0.6	8.6	82.6	0.7	0.7	1.4	60	32	8	10
8-16	AB	6.9	0.5	10.8	95.4	0.6	0.5	0.9	58	30	12	14
16-26	Bt	7.3	0.6	20.2	99.5	1.0	0.6	0.8	31	45	24	13
26-37	C	7.6	0.4	13.2	100.0	0.9	0.3	0.5	62	22	16	13
37-45	Btb	7.9	0.5	16.4	100.6	1.1	0.4	0.9	58	22	20	8
45-60	Cb	7.8	0.6	9.8	100.0	1.0	0.2	0.6	65	23	12	10
Satanta # 1-39												
0-6"	A	7.2	1.6	19.9	100.0	1.3	1.7	1.7	40	42	18	19
6-19	AB	7.3	1.4	16.6	100.6	0.8	0.4	2.2	43	37	20	23
19-44	Bt	7.2	1.9	25.4	100.6	1.5	0.4	6.9	34	34	32	13
44-54	Btk	7.5	2.1	21.8	100.0	1.9	0.2	6.5	41	31	28	36
54-60	Ck	7.7	1.8	12.4	100.0	1.8	0.1	5.2	64	20	16	18
Satanta # 16												
0-6"	A1	6.8	0.4	18.2	93.0	0.2	0.8	1.3	57	23	20	15
6-9	A2	6.3	0.3	17.0	77.0	0.1	0.5	1.4	56	24	20	6
9-24	Bt	7.1	0.5	26.0	100.0	0.5	0.5	0.9	32	36	32	20
24-39	Bk	8.8	1.2	14.3	100.0	10.1	0.2	4.6	29	53	18	21
39-52	Ck1	9.0	1.5	12.4	100.0	4.4	0.1	8.2	57	27	16	18
52-58	Ck2	7.7	6.1	19.4	100.0	3.6	0.2	9.5	26	49	25	23
58-62	2Btkyb	7.6	6.2	24.1	100.0	3.2	0.2	9.2	45	24	31	8

Appendix E. Soil Chemical and Physical Properties (cont.).

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	Particle Size sand (%)	silt (%)	clay (%)	VFS (%)
Satanta # 36-12												
0-8"	A	7.0	0.5	16.7	99.4	0.2	0.8	0.7	43	39	18	18
8-18	Bt	7.3	1.0	25.1	100.0	1.6	0.7	0.8	36	36	28	13
18-36	Btk	8.0	0.8	21.1	100.0	15.2	0.4	1.4	26	42	32	22
36-50	Ck1	8.3	0.9	20.7	100.0	12.9	0.3	2.1	24	48	28	21
50-57	Ck2	8.4	0.9	17.5	100.0	12.4	0.3	3.3	53	29	18	18
Satanta # 73C												
0-8"	A	6.3	0.6	14.4	77.1	0.8	1.4	1.1	68	20	12	15
8-19	AB	7.3	0.4	10.8	100.0	1.0	0.5	0.9	63	25	12	7
19-36	Bt	7.5	1.0	20.2	99.5	1.6	0.6	0.9	23	53	24	20
36-45	Btk	8.1	1.2	16.4	100.0	6.4	0.4	0.5	35	45	20	18
45-53	Ck	8.3	0.8	12.3	100.0	3.0	0.5	0.6	43	43	14	14
53-60	C1	7.9	1.2	14.7	100.0	1.8	0.3	0.8	56	26	18	10
Satanta (disturbed) # 1-43												
0-21"	Fill	7.7	1.2	19.1	100.0	5.5	0.7	2.1	49	29	22	12
21-25	Ab	7.3	1.8	13.6	100.0	0.6	0.4	3.8	53	31	16	17
25-36	Btb	7.0	4.5	19.1	99.5	2.4	0.5	6.4	41	36	23	12
36-47	Btkb	7.4	3.5	17.0	97.3	10.0	0.3	8.3	49	30	21	18
47-59	Ckb	7.9	1.4	14.3	100.0	7.0	0.2	6.1	52	30	18	7
Truckton # 78A												
0-8"	A	7.9	1.1	9.2	98.9	1.5	0.9	1.2	73	19	8	2
8-15	AB	8.2	0.9	7.8	98.7	1.1	0.5	0.9	82	10	8	9
15-43	Bt	8.0	1.0	13.8	100.7	1.0	0.5	0.7	57	27	16	5
43-60	2Btkb	8.5	1.2	25.8	100.0	39.6	0.5	2.4	19	49	32	12

Appendix E. Soil Chemical and Physical Properties (cont.).

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	Particle Size sand (%)	silt (%)	clay (%)	VFS (%)
Truckton # 2-1												
0-16"	A	6.5	0.5	1.6	75.0	0.3	0.4	1.9	82	18	<1	6
16-26	AB	6.7	0.4	10.0	91.0	0.3	0.3	1.1	76	12	12	6
26-37	Bt1	6.5	0.4	14.7	83.7	0.4	0.3	1.0	67	15	18	6
37-46	Bt2	6.8	0.4	11.1	94.6	0.5	0.2	0.8	74	12	14	4
46-60	C	7.0	0.4	9.4	98.9	0.6	0.1	1.4	73	15	12	9
Truckton (disturbed) # 2-37												
0-4	Fill	7.6	1.3	9.5	100.0	3.2	0.5	1.8	78	12	10	5
4-10	Bt	7.8	0.9	11.5	100.0	0.7	0.3	2.3	69	17	14	10
10-25	C1	7.8	0.8	8.3	98.8	3.0	0.2	2.9	77	13	10	10
25-49	Ck1	8.4	0.9	8.1	100.0	5.3	0.2	3.0	73	17	10	10
49-60	Ck2	8.3	0.8	6.4	101.6	5.1	0.1	2.1	77	15	8	8
Typic Haplustoll # 23D												
0-5"	A1	6.1	0.7	28.9	71.2	1.9	0.9	1.0	30	36	34	19
5-12	Bw	7.1	1.1	26.1	100.0	2.2	0.6	1.3	30	38	32	20
12-27	Bk1	7.9	1.1	23.9	99.0	15.4	0.4	0.9	26	44	30	23
27-42	Bk1	8.2	1.0	24.9	100.0	13.0	0.2	1.5	22	46	32	29
42-60	Ck	8.2	0.9	24.8	100.0	10.1	0.2	1.5	39	29	32	13

Appendix E. Soil Chemical and Physical Properties (cont.).

Soil Series (depth)	Horizon Design.	pH	EC (mmhos /cm)	CEC (meq/ 100g)	Base Sat. (%)	Lime (%)	O.C. (%)	SAR	Particle Size sand (%)	silt (%)	clay (%)	VFS (%)
Typic Haplustoll # 77												
0-9"	A	7.0	0.5	9.5	100.0	0.2	0.5	1.6	81	9	10	10
9-19	AB	7.4	0.3	13.2	100.0	0.2	0.3	1.2	71	13	16	8
19-30	Bw1	7.3	0.3	10.2	100.0	0.2	0.3	0.8	73	15	12	13
30-40	Bw2	7.9	0.4	17.5	100.0	0.3	0.3	0.4	64	14	22	2
40-52	C1	8.4	0.6	11.1	100.0	0.5	0.2	0.8	84	2	14	10
52-67	C2	8.3	0.7	9.4	100.0	2.1	0.2	0.6	86	2	12	14
Weld # 12												
0-9"	A	6.5	1.1	19.8	82.8	1.8	0.9	0.7	39	39	22	16
9-21	Bt	7.7	1.0	29.0	100.3	9.5	0.5	1.0	19	45	36	15
21-39	BCk	8.2	0.8	23.7	100.0	22.7	0.3	1.5	12	58	30	10
39-58	C1	8.2	1.0	22.5	100.4	12.4	0.2	2.0	19	52	29	17
58-63	C2	8.1	1.1	23.4	100.0	5.2	0.4	1.4	44	27	29	13

7.0 HOW TO USE THE SOIL MAP

This section contains information related to the soil map(s) and includes a map legend and index to the map sheets (figure 3). To use the soil map which accompanies this report, first determine which map sheet covers your area of interest by referring to figure 3. The map sheets are numbered using section numbers, so that section 1 is on map sheet 1. Next, locate the specific area of proposed activity on the soil map and determine which map symbols occur there. Write these symbols down and refer to the map legend to determine the name of the map units. Once the names of the map units and soils are known, read the description of the soils and map units (section 3.4) and compare it with what you observe on the ground. You may then want to refer to the tables of soil properties and interpretations contained in sections 3.5 and 3.6.

This survey was conducted at a high level of intensity and should be precise enough for most uses. However, in using the soil map and report it is important to remember that soils are inherently variable and that both similar and dissimilar inclusions may occur. This report is not a substitute for on-site investigations for projects where information of a very specific nature is important.

7.1 Map Legend

Soil Map Unit Legend

AsA	Ascalon sandy loam, 0-1% slopes	14
AsB	Ascalon sandy loam, 1-3% slopes	
AsC	Ascalon sandy loam, 3-6% slopes	
AsD	Ascalon sandy loam, 6-10% slope	
BrA	Bresser sandy loam, 0-1% slopes	16
BrB	Bresser sandy loam, 1-3% slopes	
BrC	Bresser sandy loam, 3-6% slopes	
BrD	Bresser sandy loam, 6-10% slopes	
BsA	Bresser-Satanta sandy loam complex, 0-1% slopes	
BsB	Bresser-Satanta sandy loam complex, 1-3% slopes	
Ca	Petrocalcic Paleustolls, 1-3% slopes	21
Fa	Aquic Haplustolls, sandy loam-loam, 0-3% slopes	12
NuA	Nunn clay loam, 0-1% slopes	19
NuB	Nunn clay loam, 1-3% slopes	
SaA	Satanta loam, 0-1% slopes	23
SaB	Satanta loam, 1-3% slopes	
SaC	Satanta loam, 3-6% slopes	
SaD	Satanta loam, 6-10% slopes	
TrB	Truckton loamy sand, 1-3% slopes	25
TrC	Truckton loamy sand, 3-6% slopes	
TrD	Truckton loamy sand, 6-10% slopes	
Th	Typic Haplustolls, sandy loam, 0-3% slopes	27
WeA	Weld loam, 0-1% slopes	29
WeB	Weld loam, 1-3% slopes	
DLS	Disturbed land sandy, 0-3% slopes	31
DLL	Disturbed land loamy, 0-3% slopes	
DLC	Disturbed land clayey 0-3% slopes	

Cultural and other map symbols

Main road A ST

Railroad tracks

Powerline

Dams, Dikes DAM

Levee

Windmill

Survey boundary Limit of Soil Survey

Soil pedon description location

Irrigation or Drainage ditch

Intermittent stream

Lake or pond LAKE

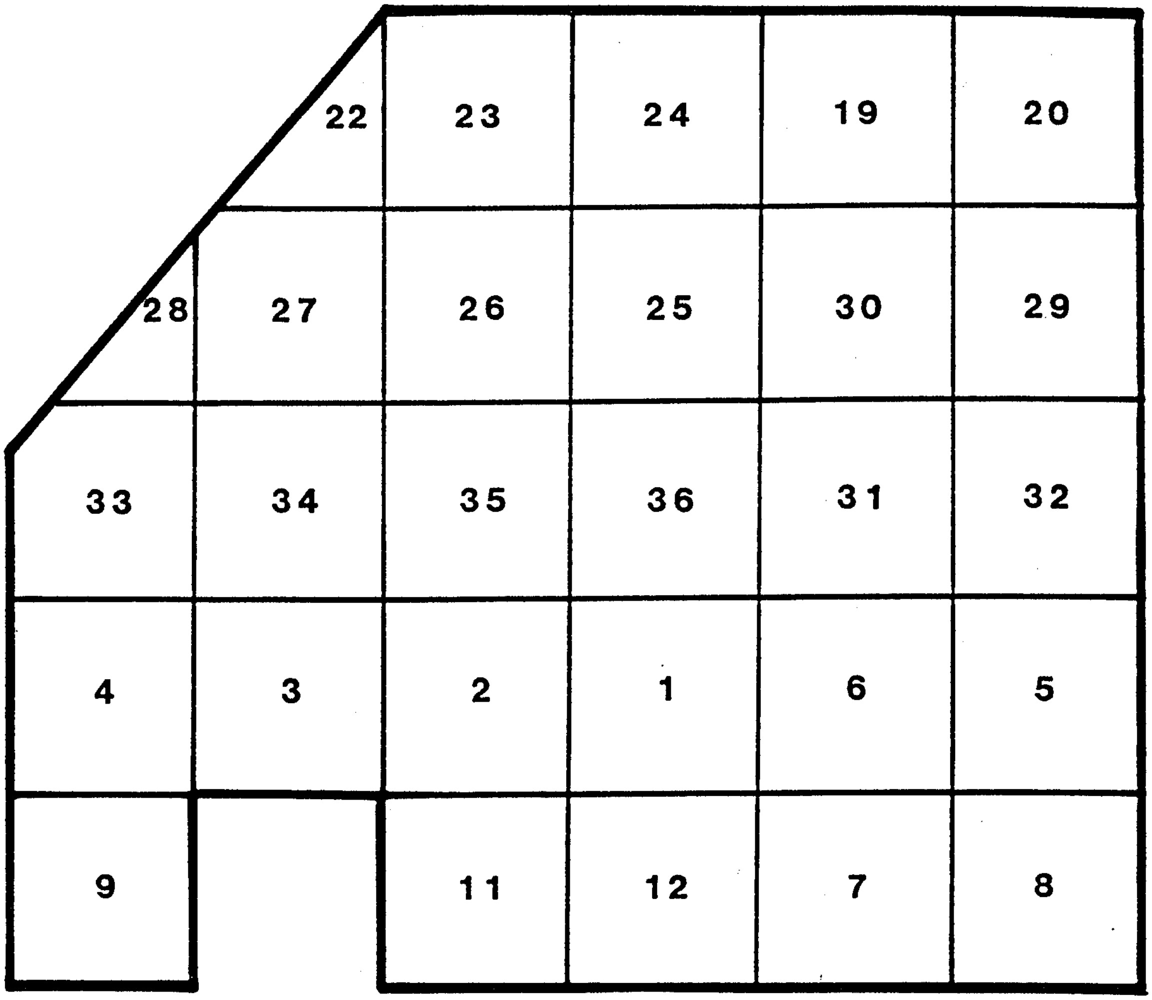
Wet spot

Surface gravel

Soil observation location

Soil boundary and symbol BrC BrB

INDEX TO MAP SHEETS



Rocky Mountain Arsenal

Adams County, Colorado

Scale

0 1 2

miles

Index to Map Sheets

James P. Walsh & Associates, Inc. | **Figure 3**

Map Legend, Rocky Mountain Arsenal

Soil Map Unit Legend

AsA	Ascalon sandy loam, 0-1% slopes
AsB	Ascalon sandy loam, 1-3% slopes
AsC	Ascalon sandy loam, 3-6% slopes
AsD	Ascalon sandy loam, 6-10% slope
BrA	Bresser sandy loam, 0-1% slopes
BrB	Bresser sandy loam, 1-3% slopes
BrC	Bresser sandy loam, 3-6% slopes
BrD	Bresser sandy loam, 6-10% slopes
BsA	Bresser-Satanta sandy loam complex, 0-1% slopes
BsB	Bresser-Satanta sandy loam complex, 1-3% slopes
Ca	Petrocalcic Paleustolls, 1-3% slopes
Fa	Aquic Haplustolls, sandy loam-loam, 0-3% slopes
NuA	Nunn clay loam, 0-1% slopes
NuB	Nunn clay loam, 1-3% slopes
SaA	Satanta loam, 0-1% slopes
SaB	Satanta loam, 1-3% slopes
SaC	Satanta loam, 3-6% slopes
SaD	Satanta loam, 6-10% slopes
TrB	Truckton loamy sand, 1-3% slopes
TrC	Truckton loamy sand, 3-6% slopes
TrD	Truckton loamy sand, 6-10% slopes
Th	Typic Haplustolls, sandy loam, 0-3% slopes
WeA	Weld loam, 0-1% slopes
WeB	Weld loam, 1-3% slopes
DLS	Disturbed land sandy, 0-3% slopes
DLL	Disturbed land loamy, 0-3% slopes
DLC	Disturbed land clayey 0-3% slopes

Cultural and other map symbols

Main road A ST.

Railroad tracks

Powerline

Dams, Dikes DAM

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Soil pedon description location

Irrigation or Drainage ditch

Intermittent stream

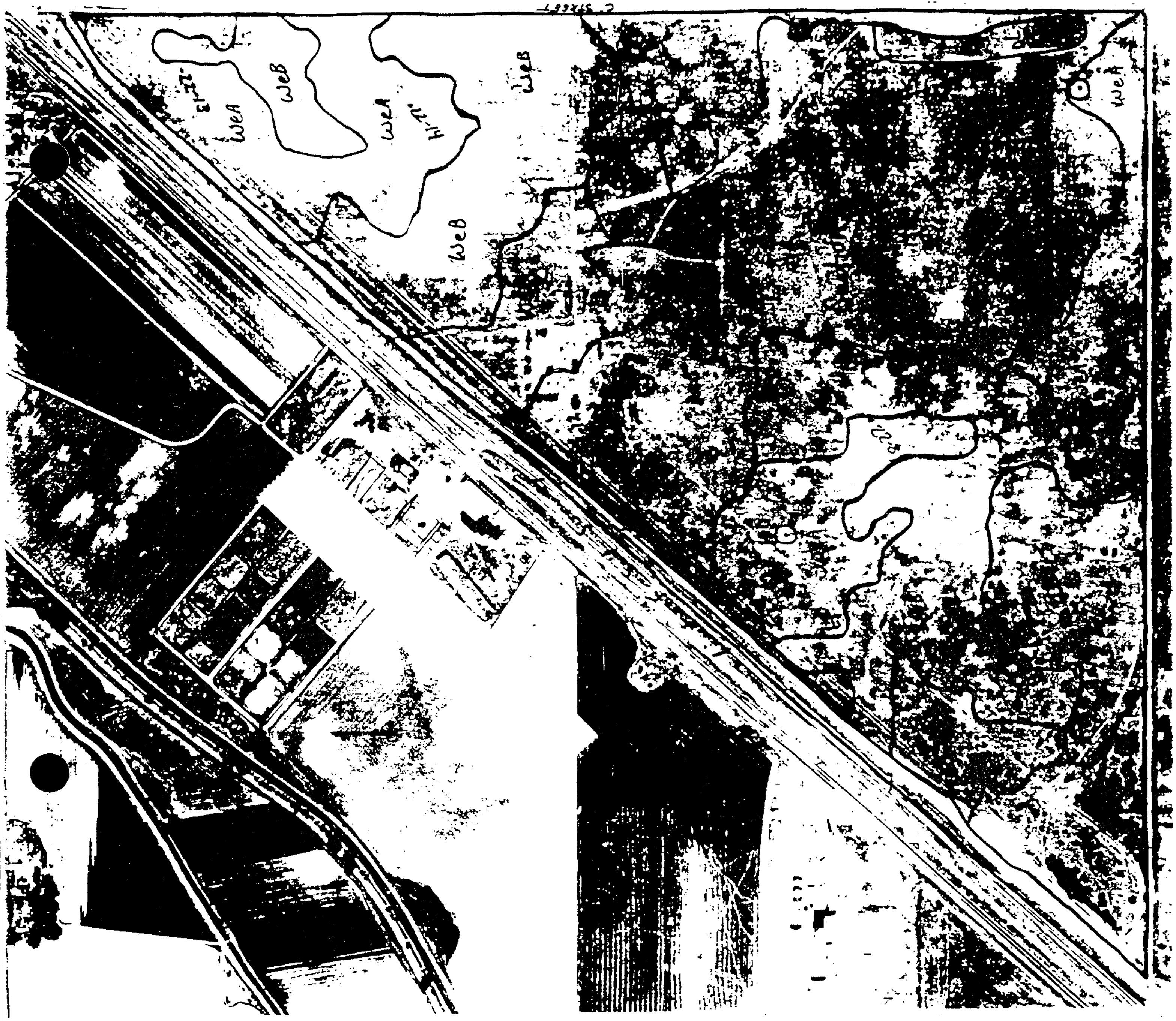
Lake or pond LAKE

Wet spot

Surface gravel

Soil observation location

Soil boundary and symbol BrC BrB



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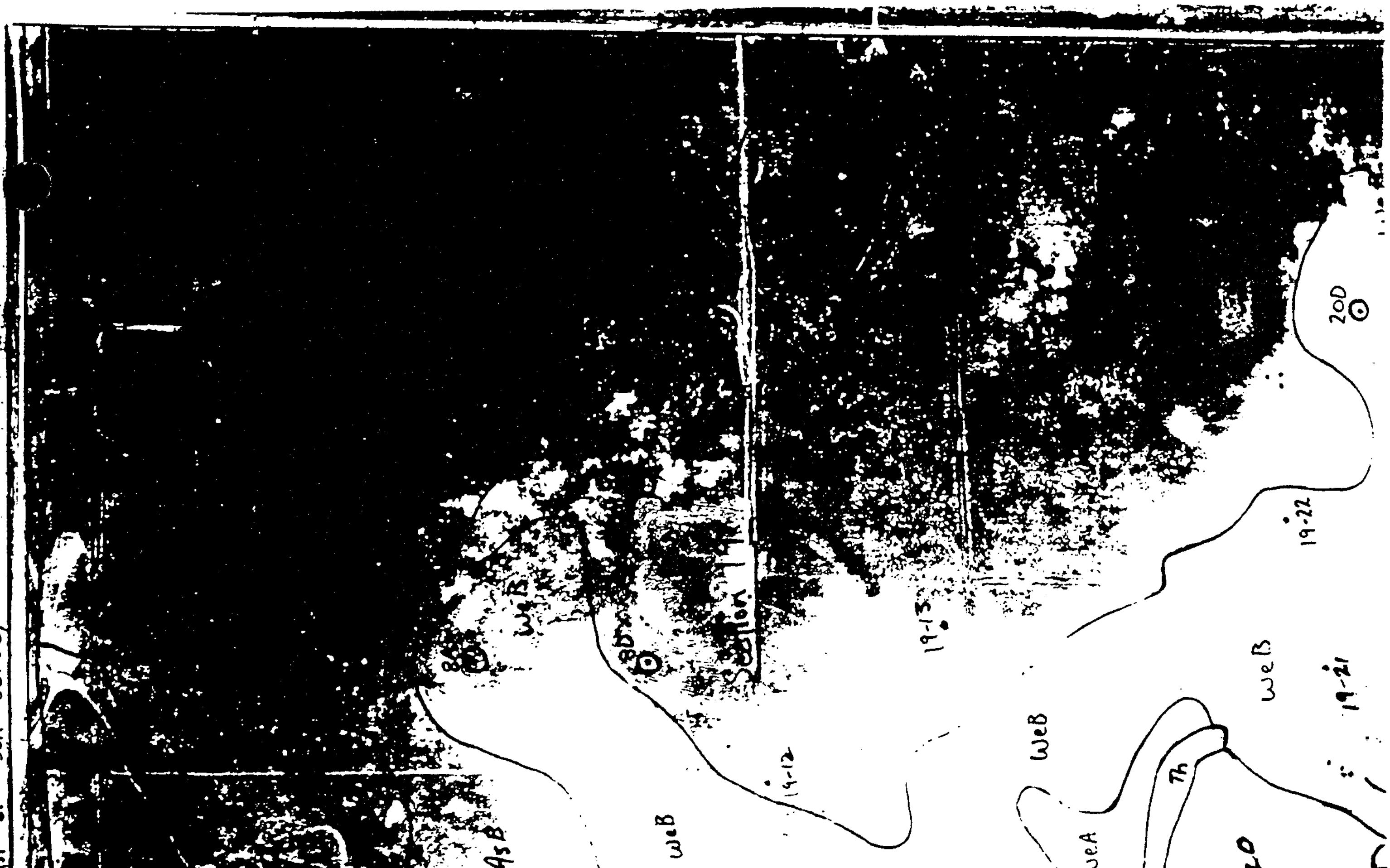

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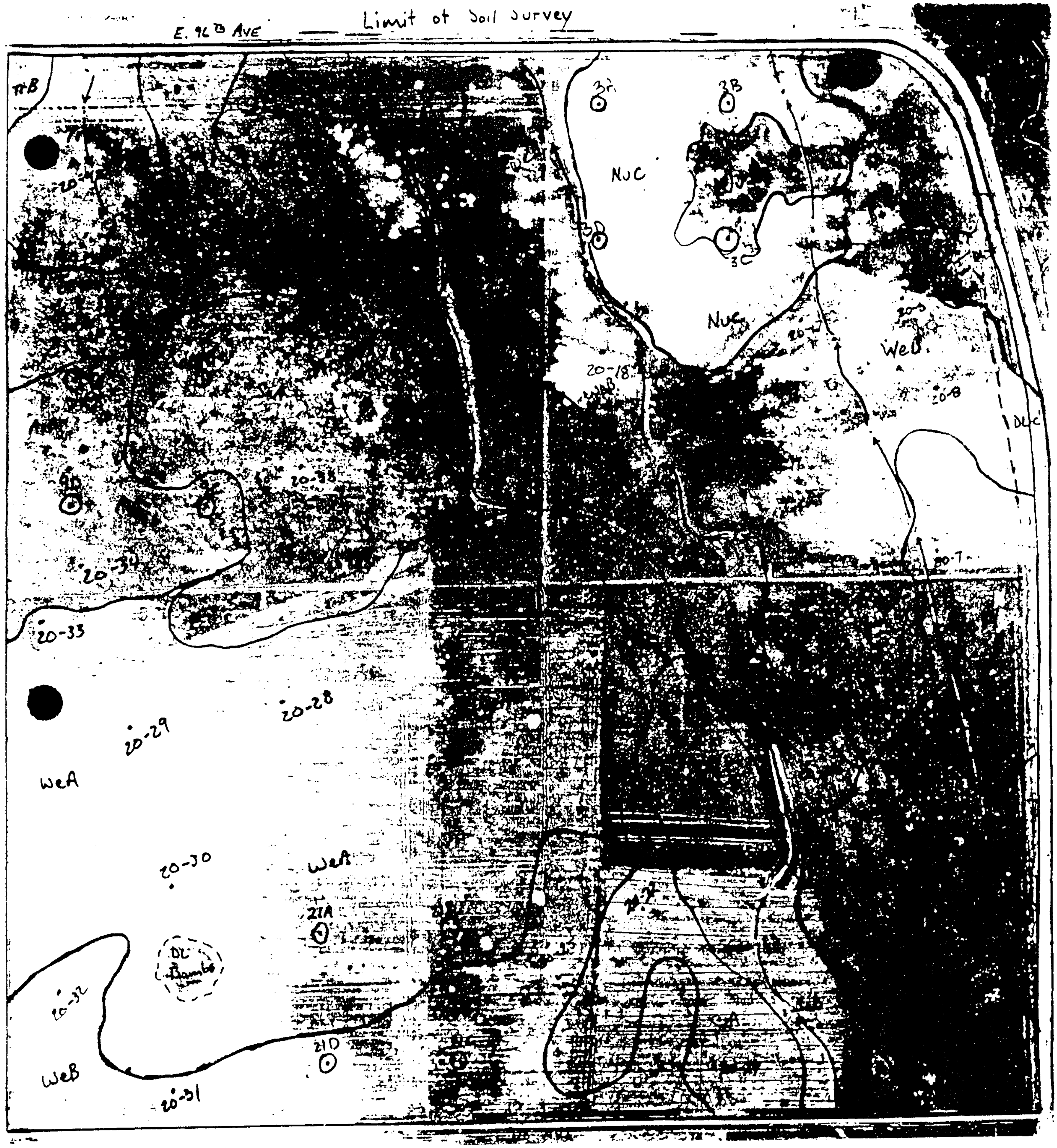

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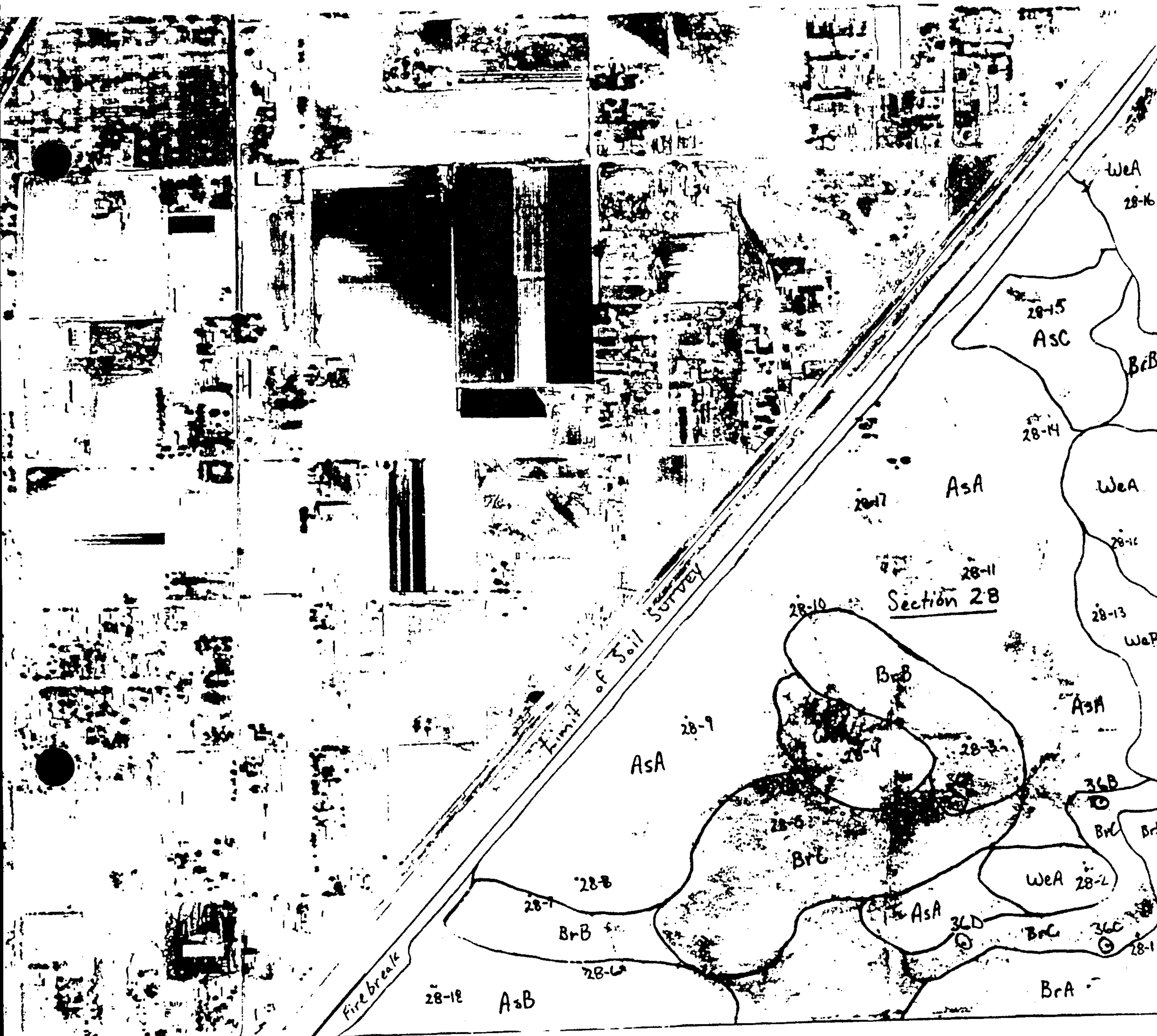

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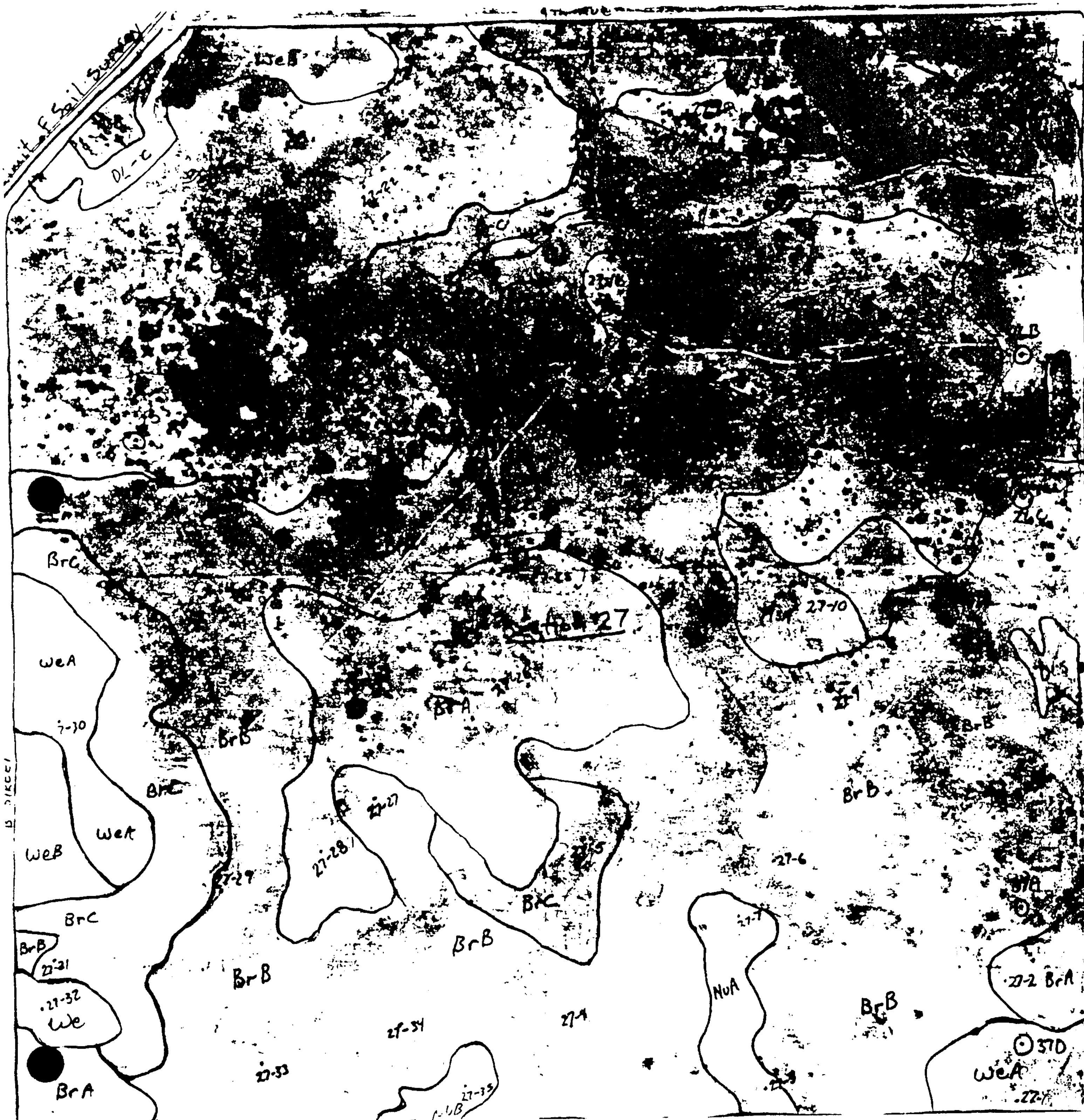

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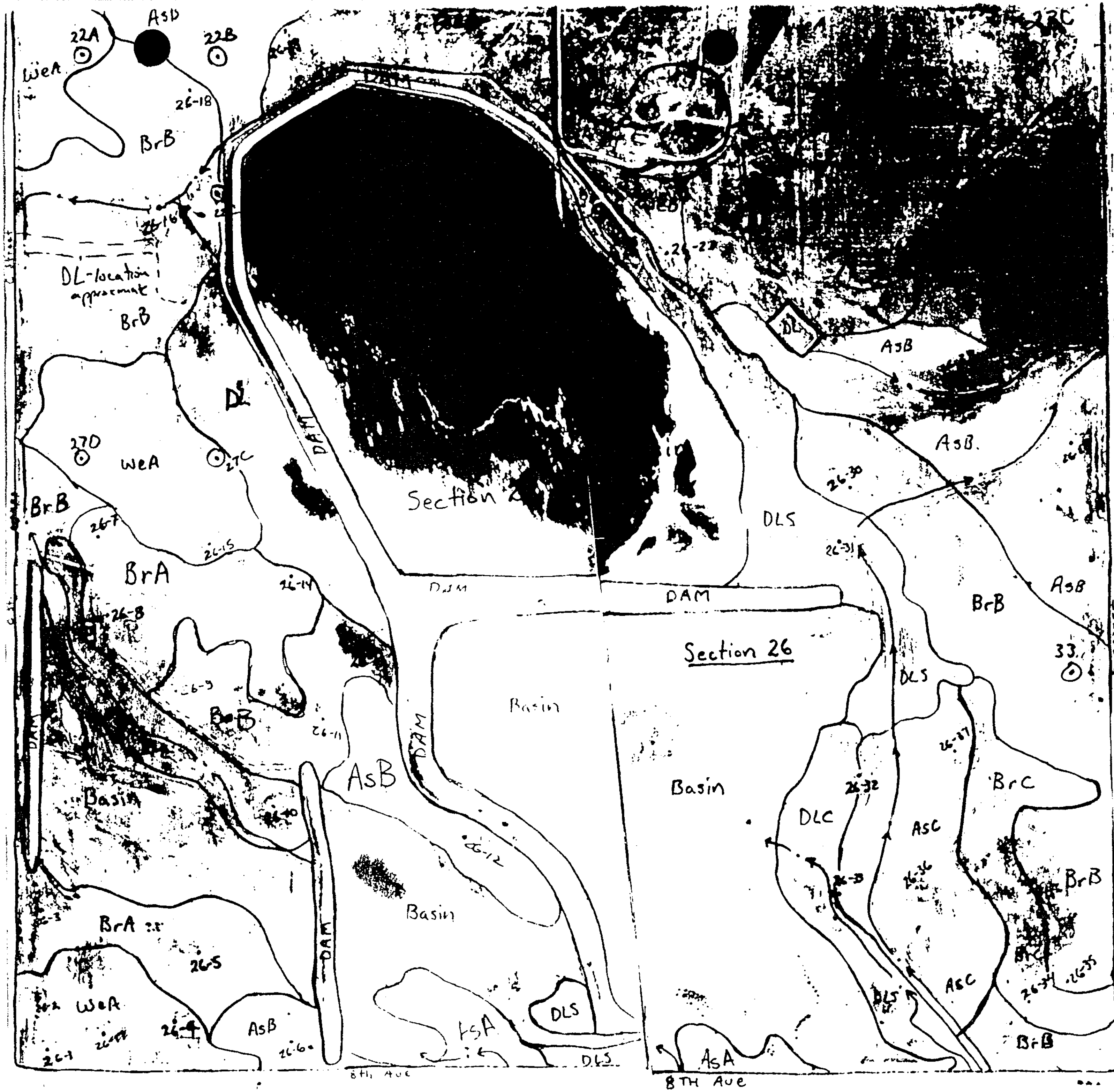

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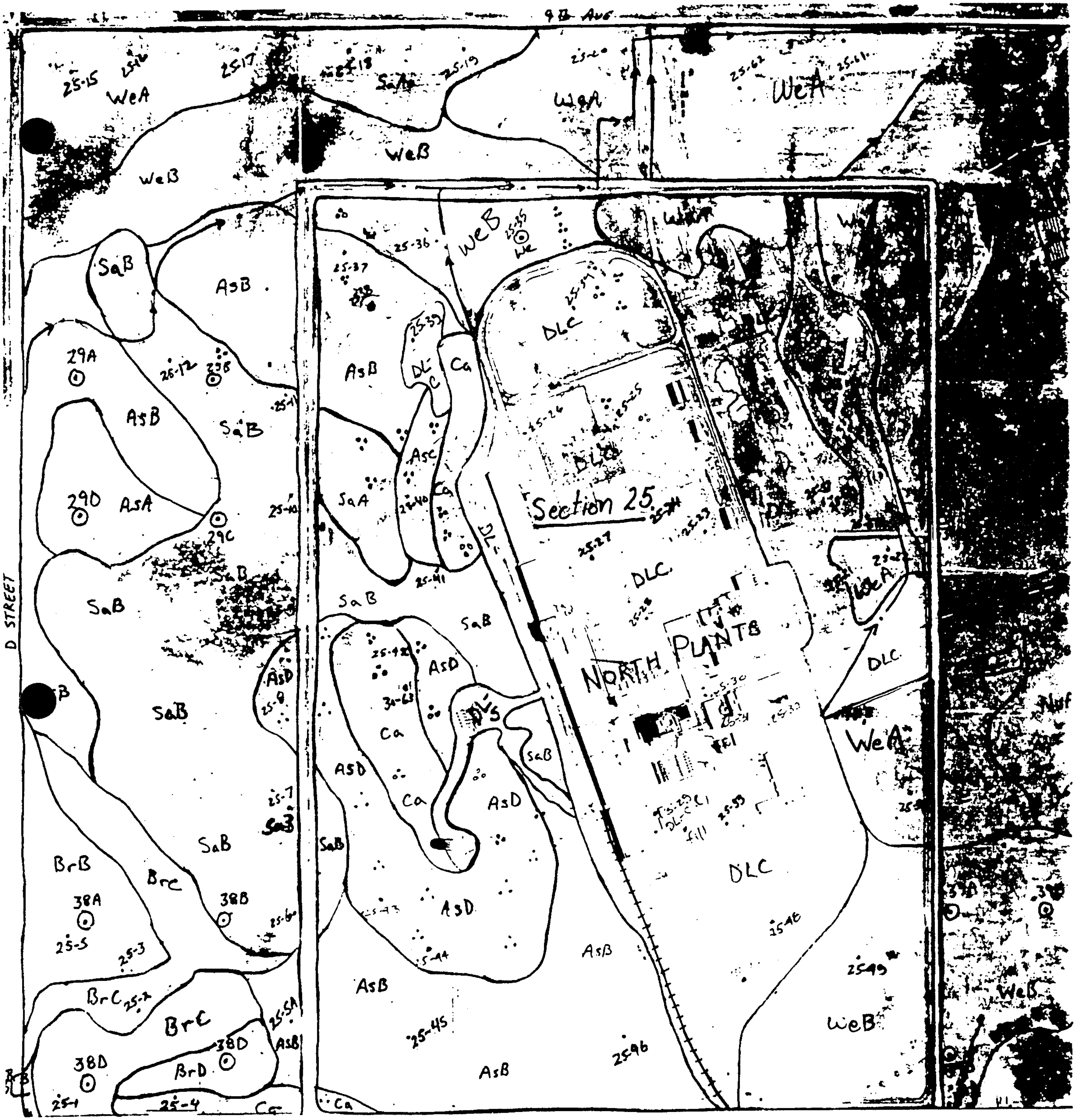

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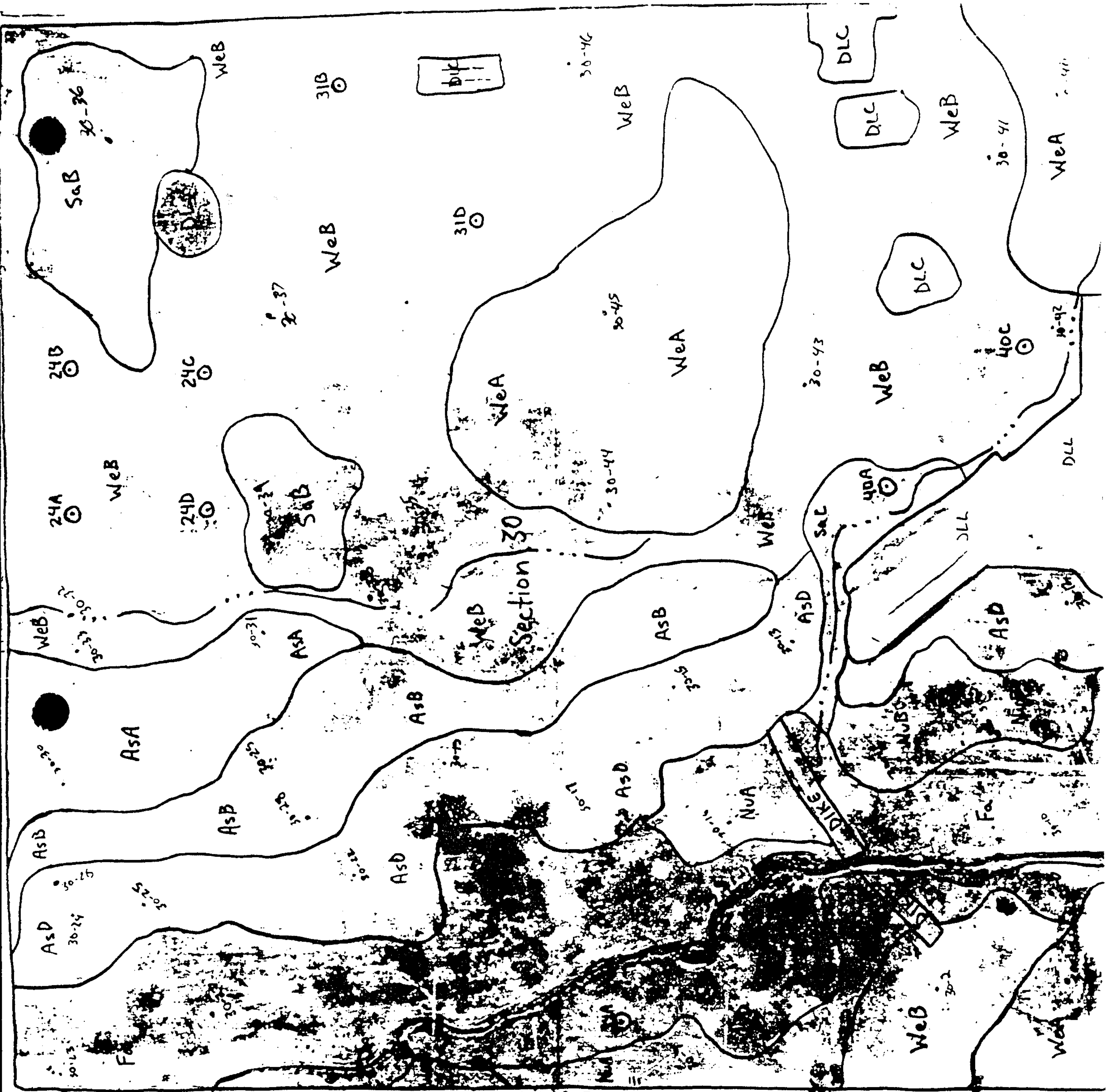

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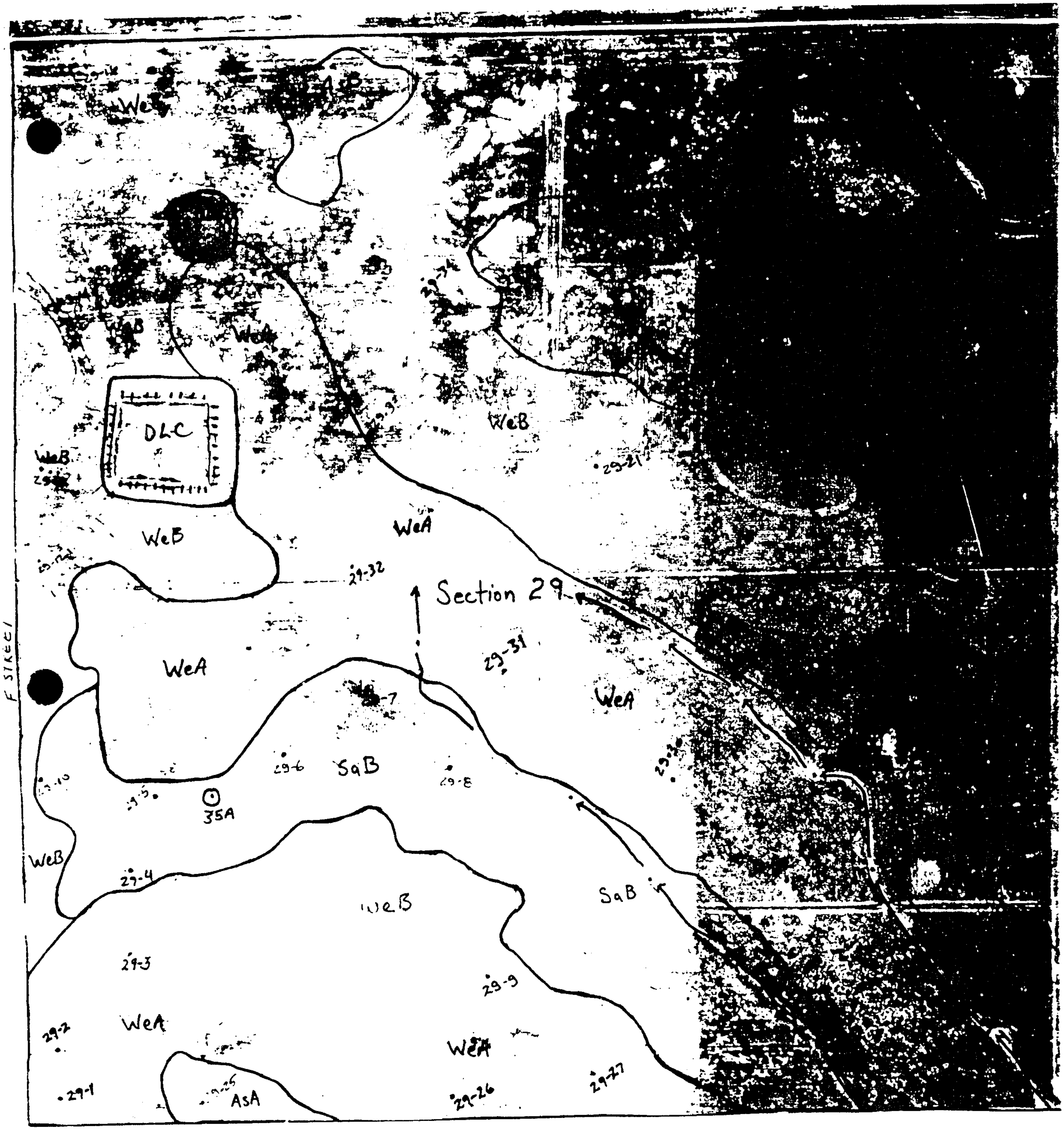

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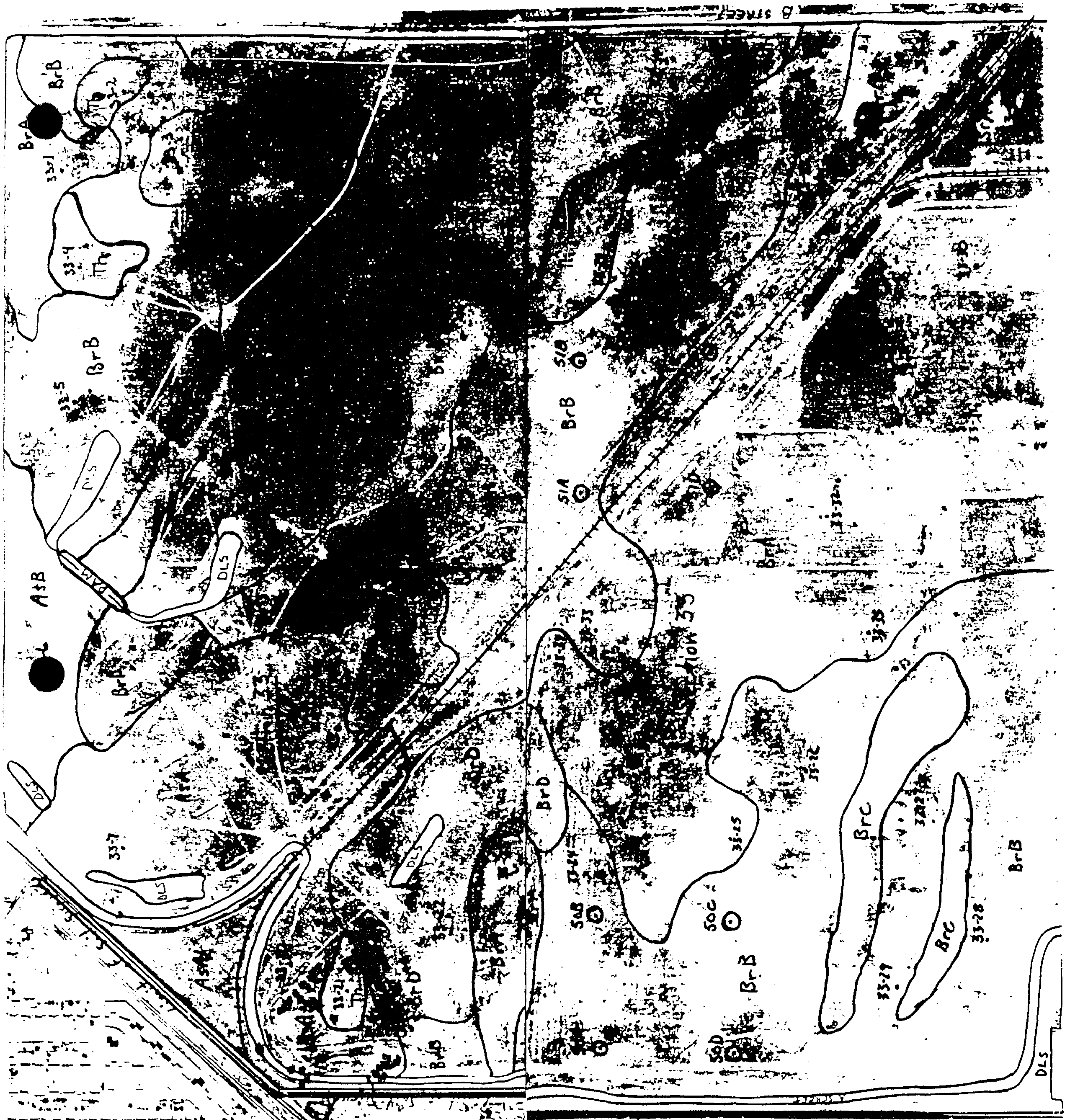

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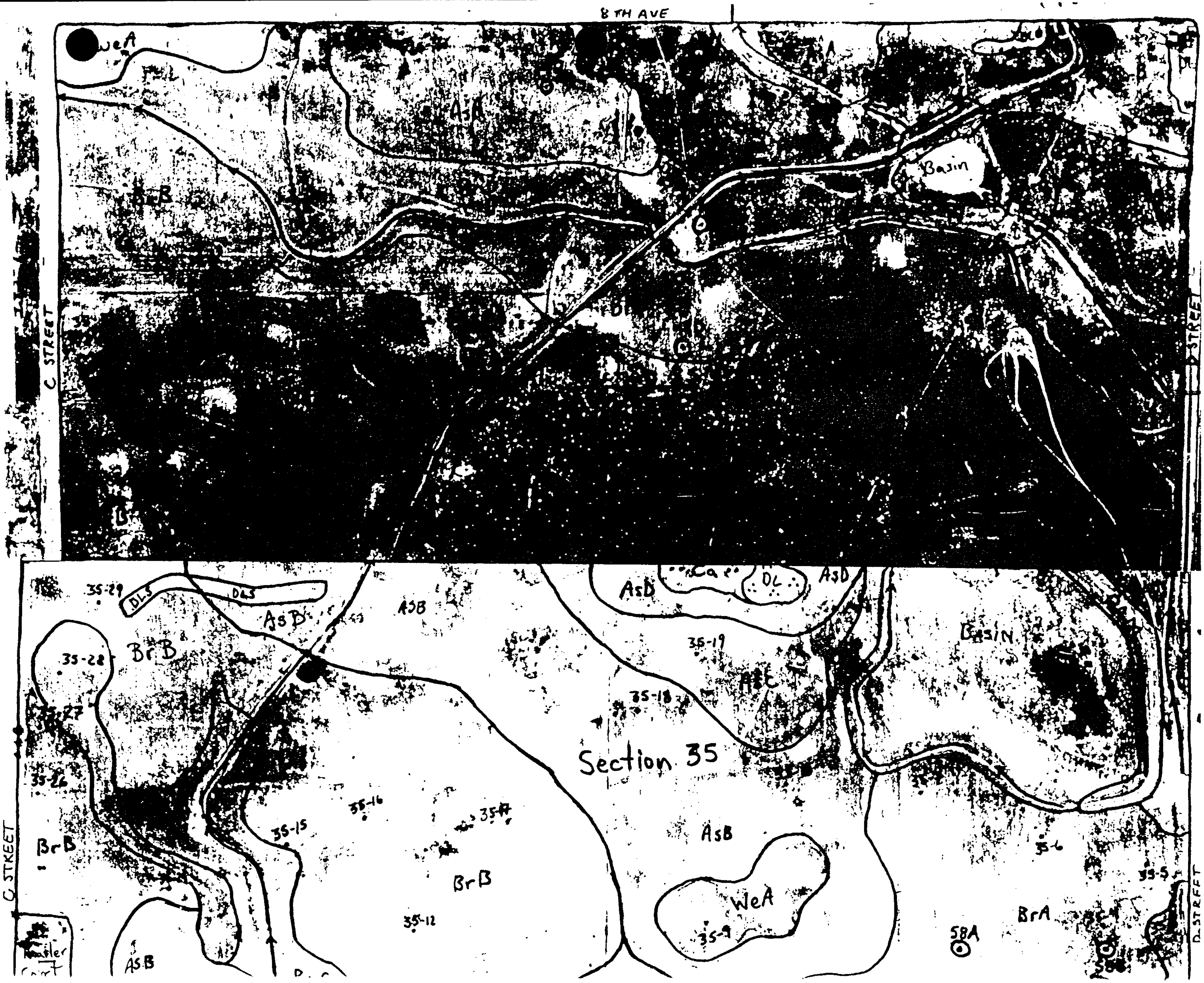
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C STREET
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AsC
Section 35
35-16
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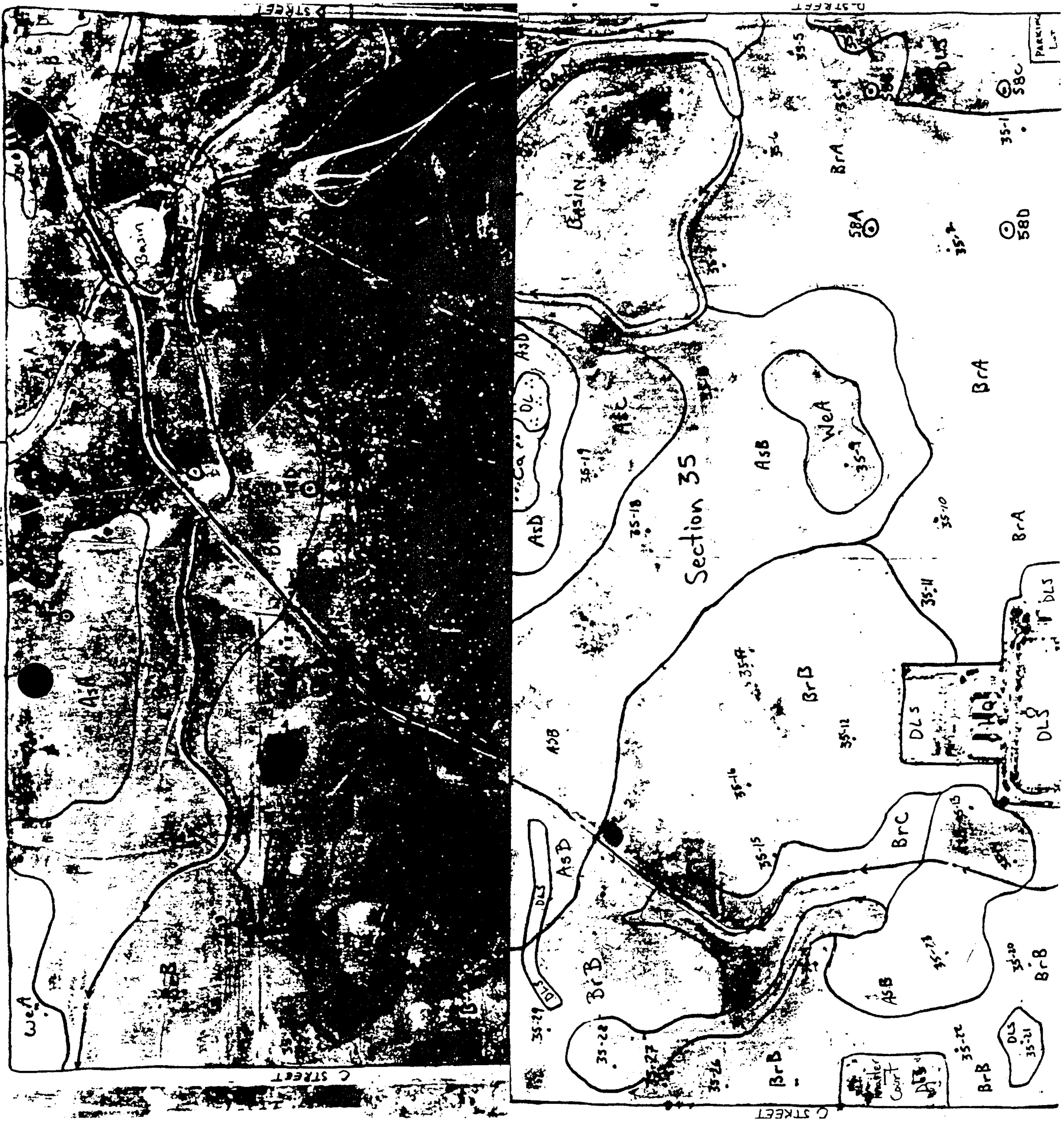

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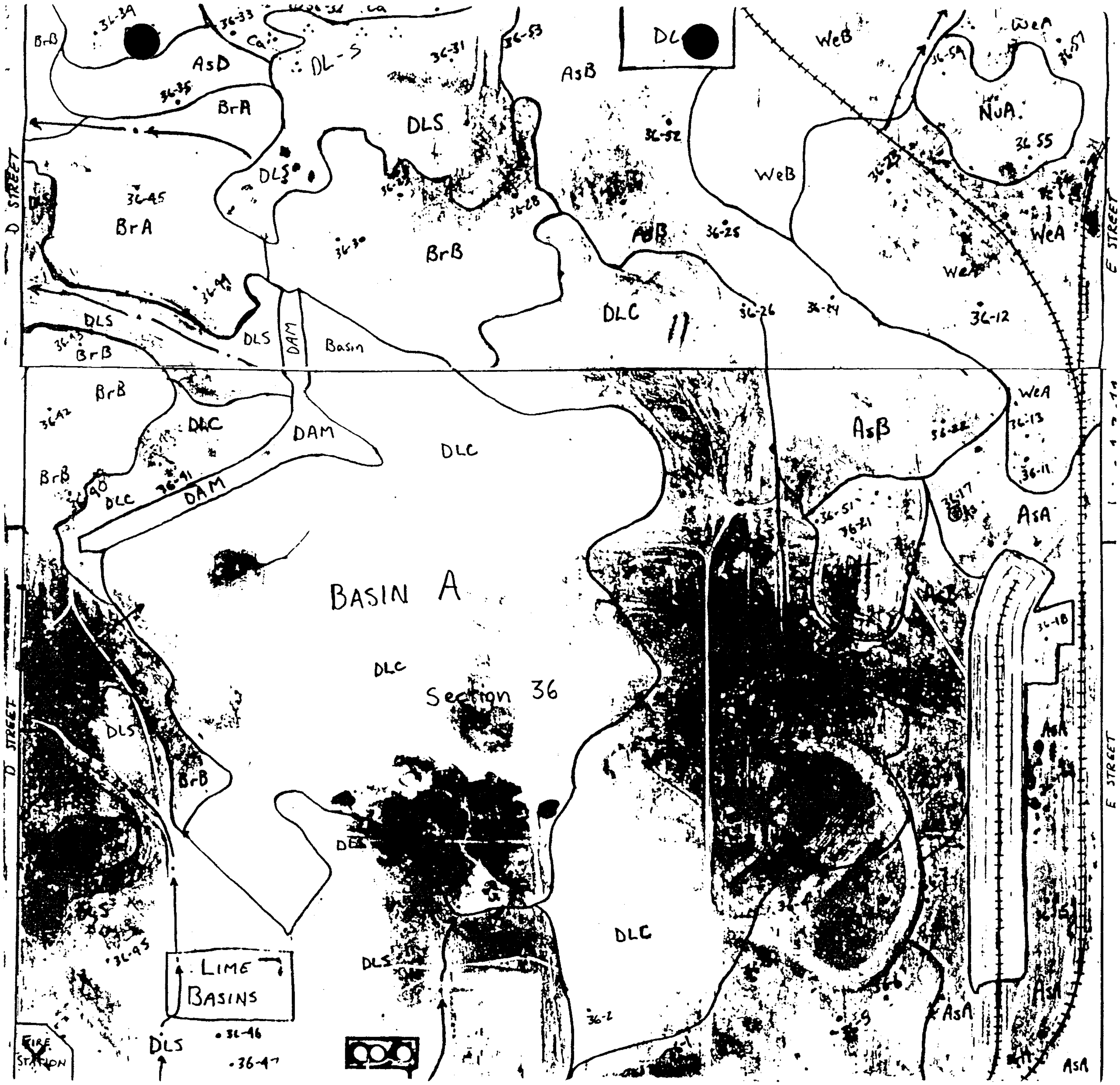

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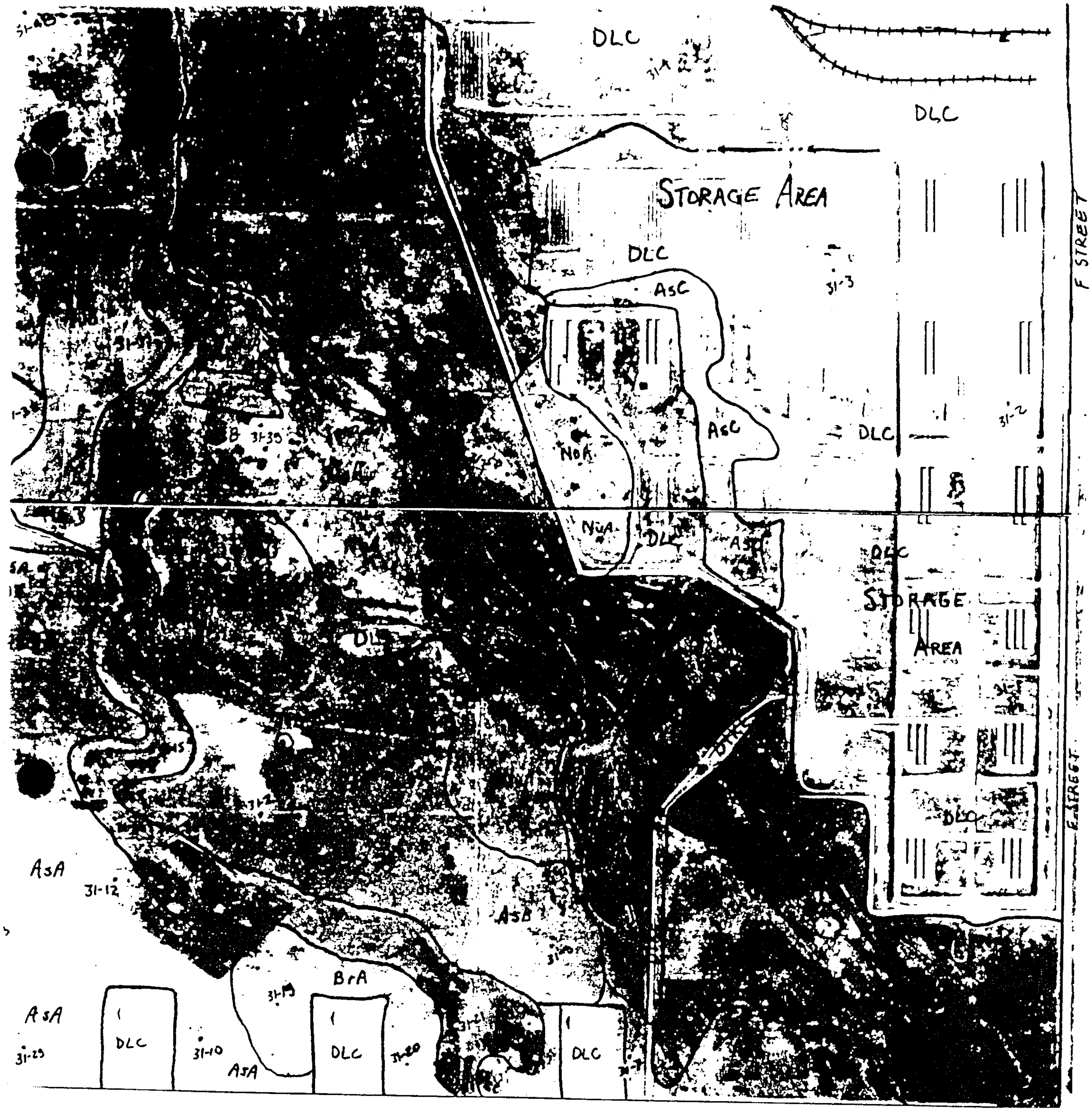

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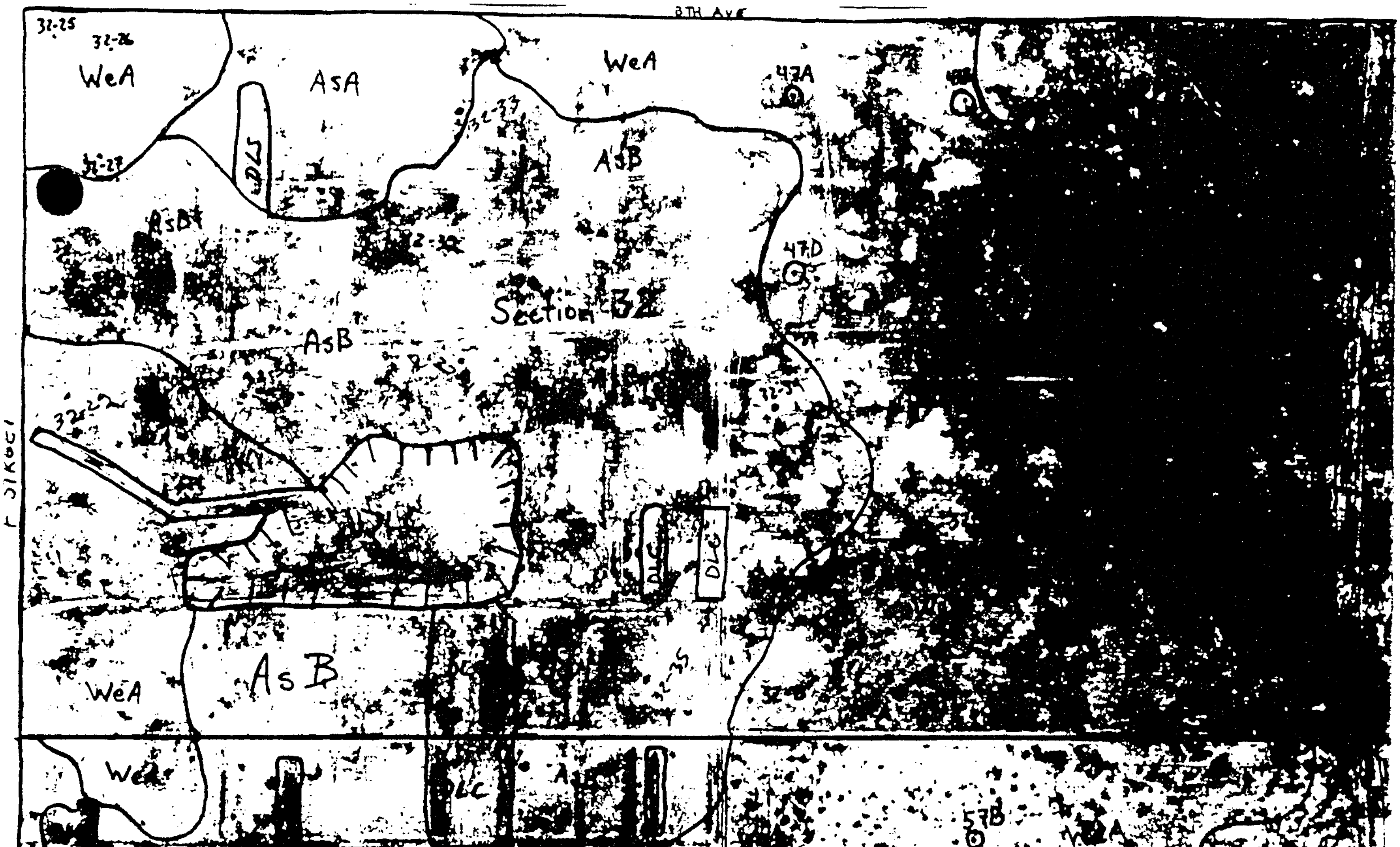

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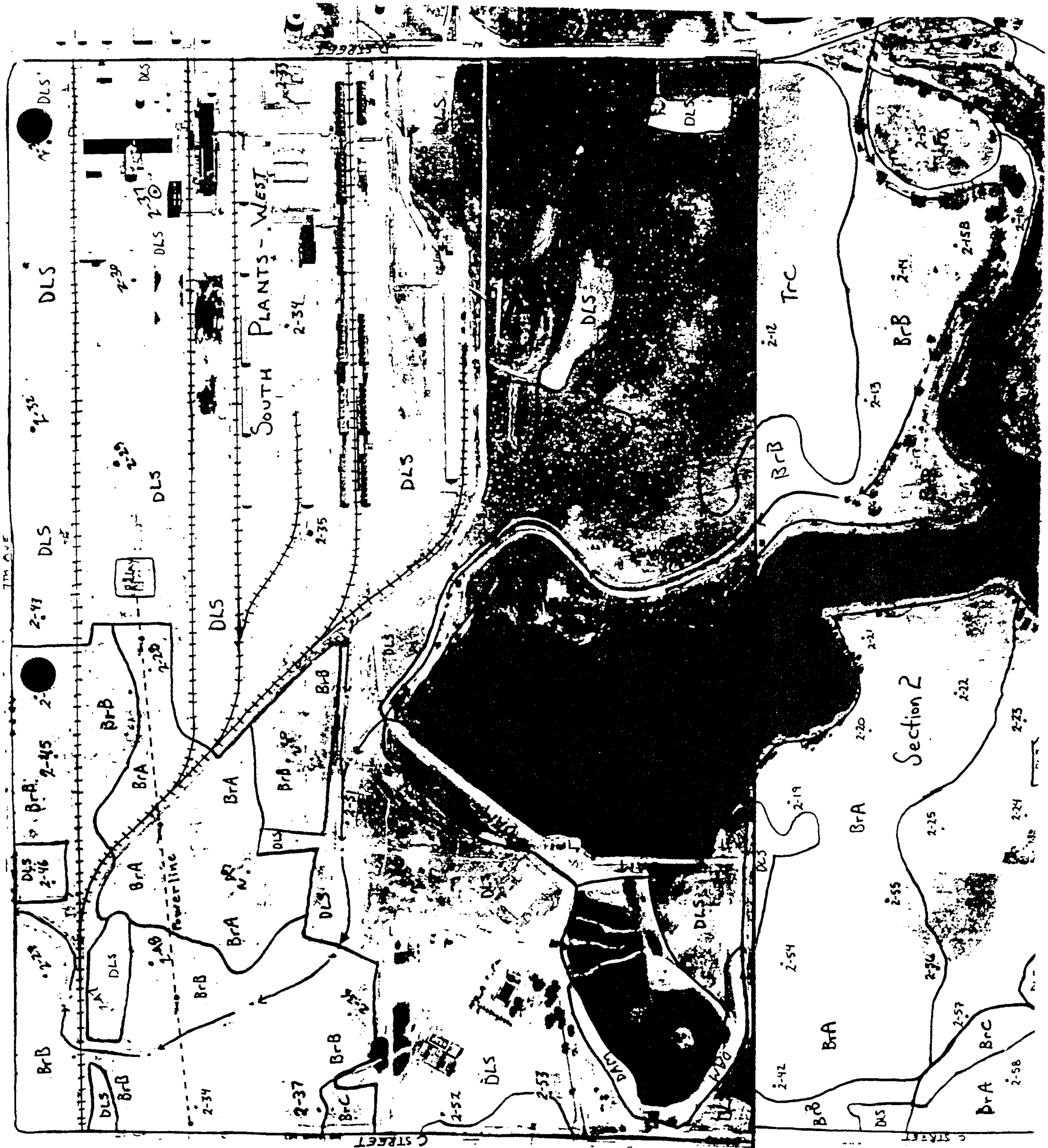

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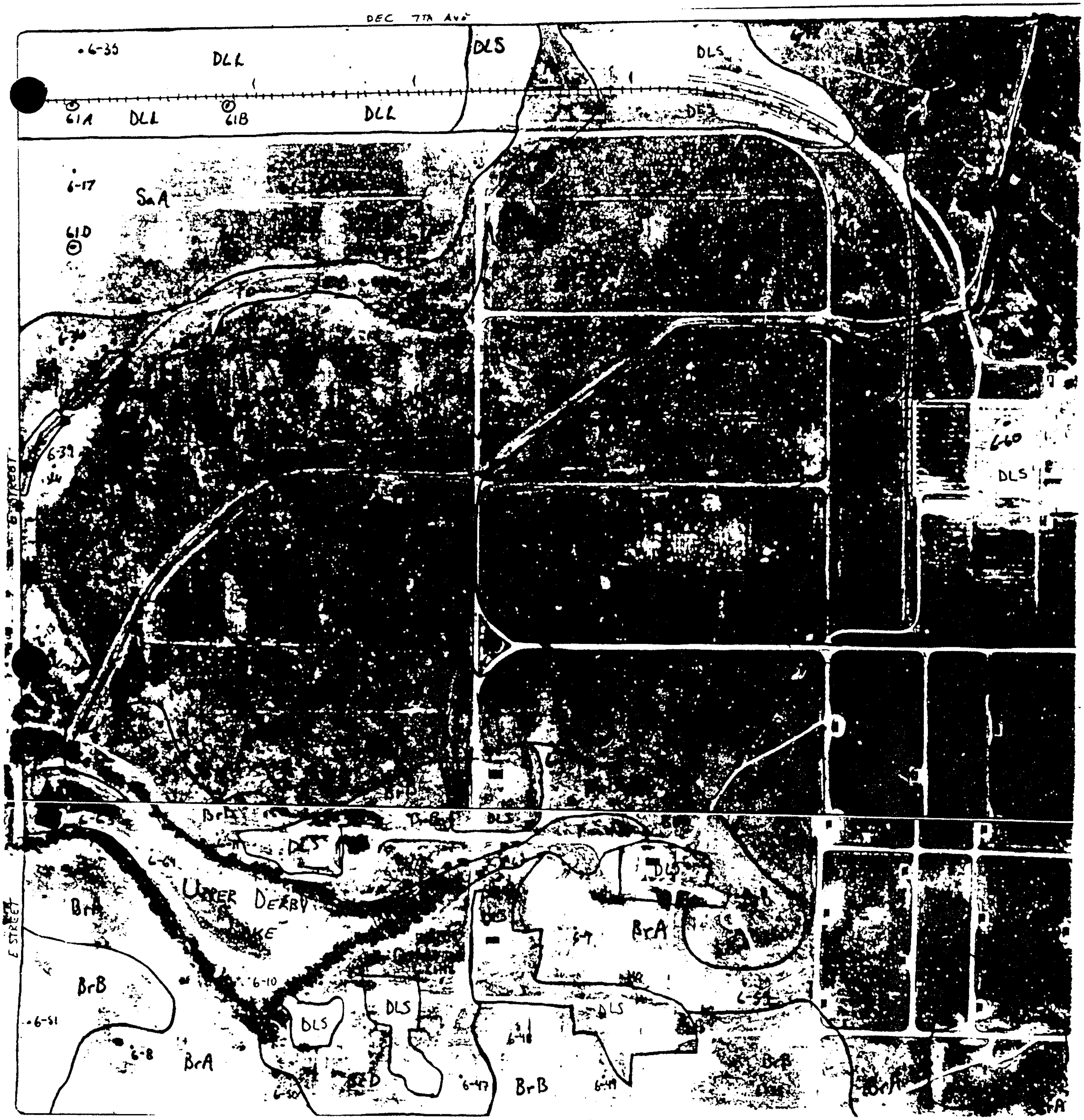

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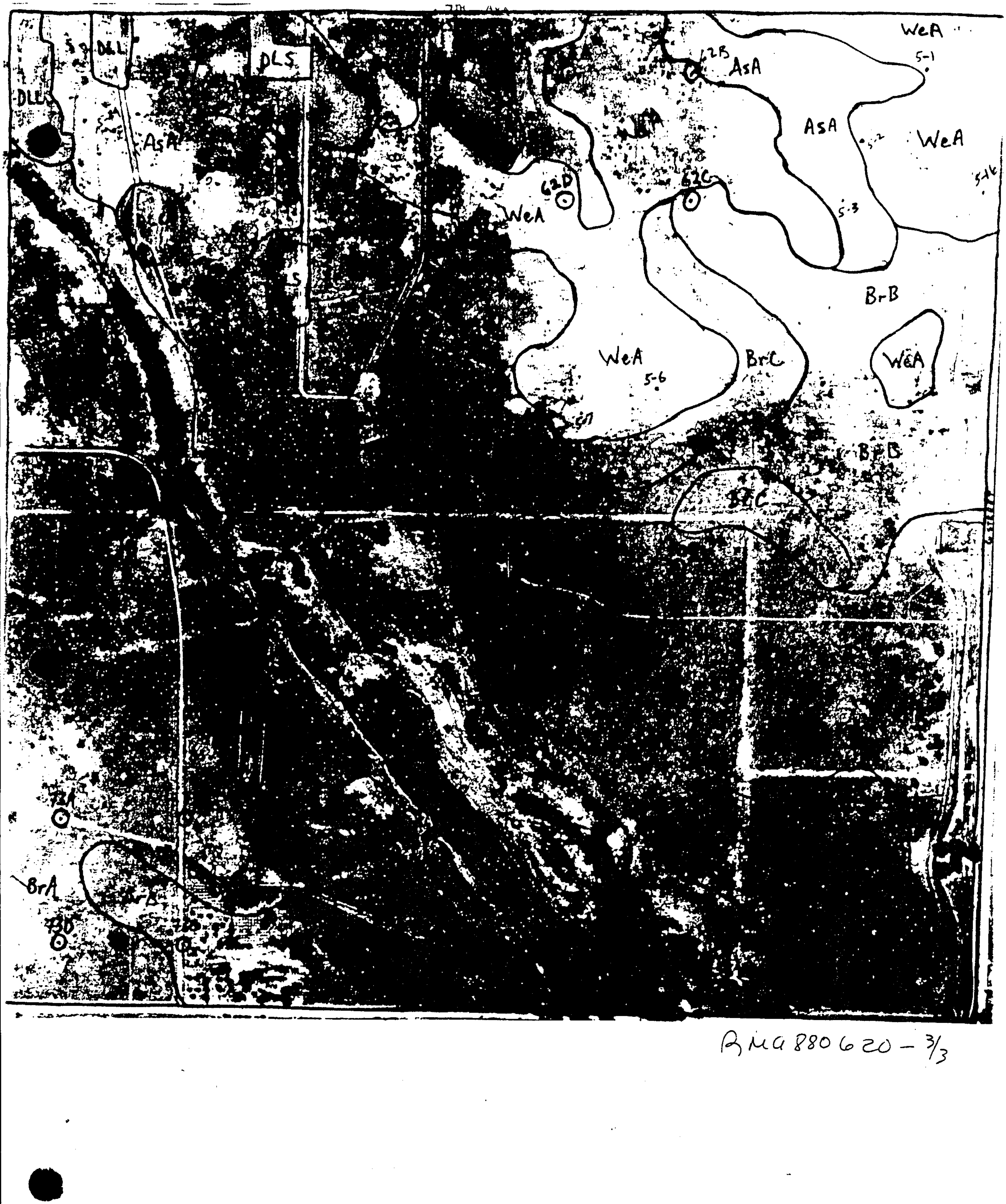

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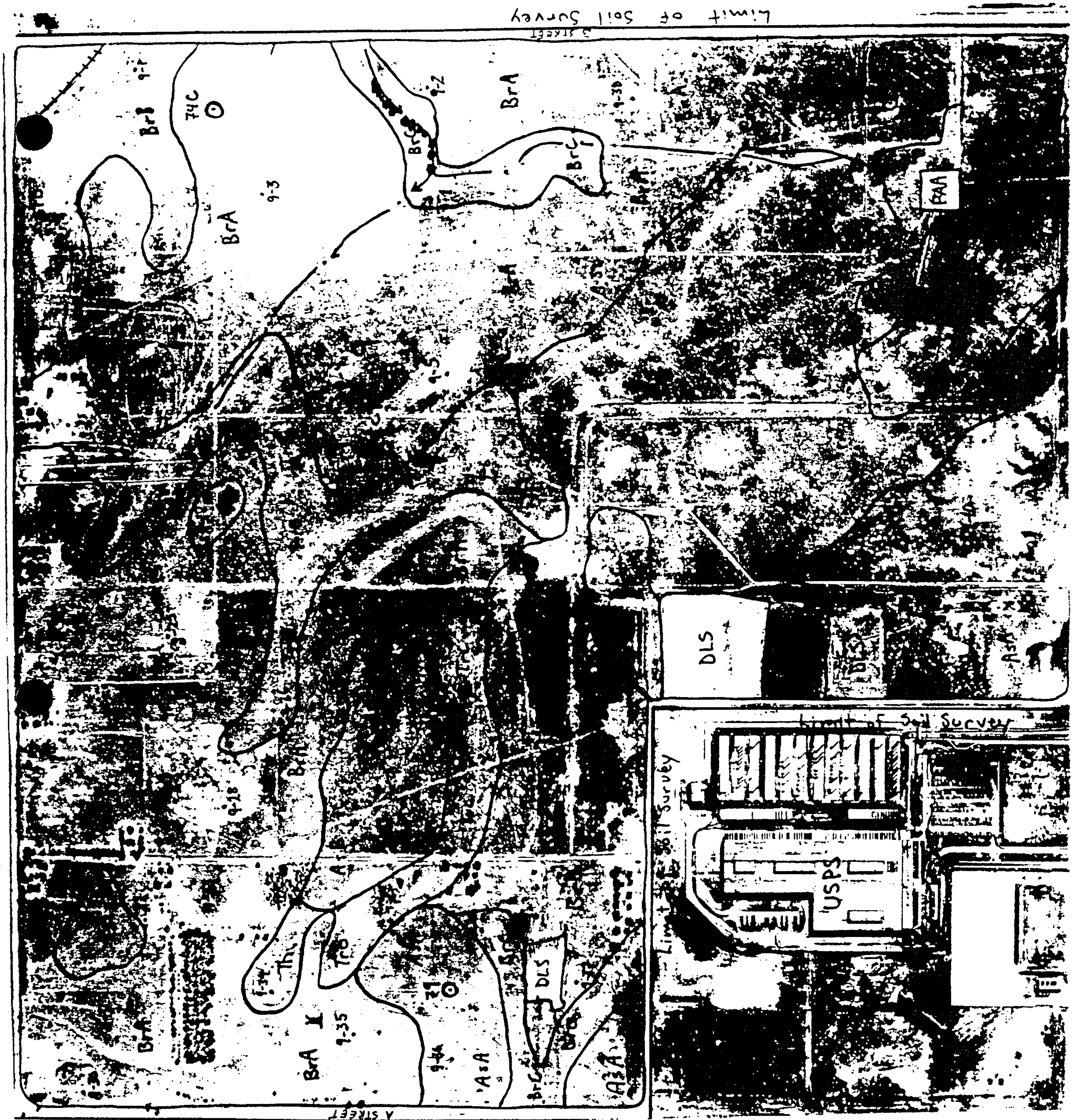

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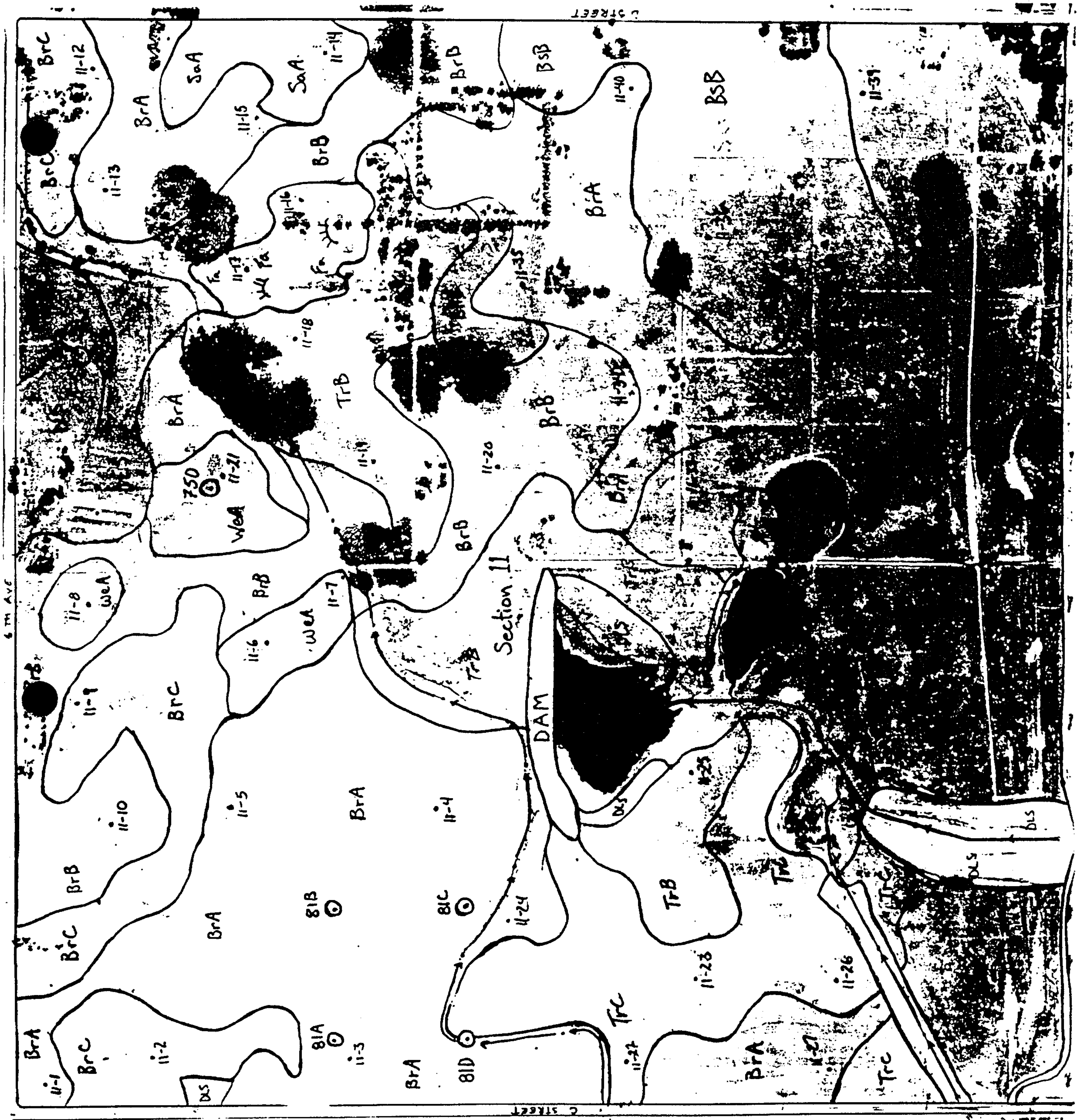

STAPLETON Limit of Soil Survey AIRPORT

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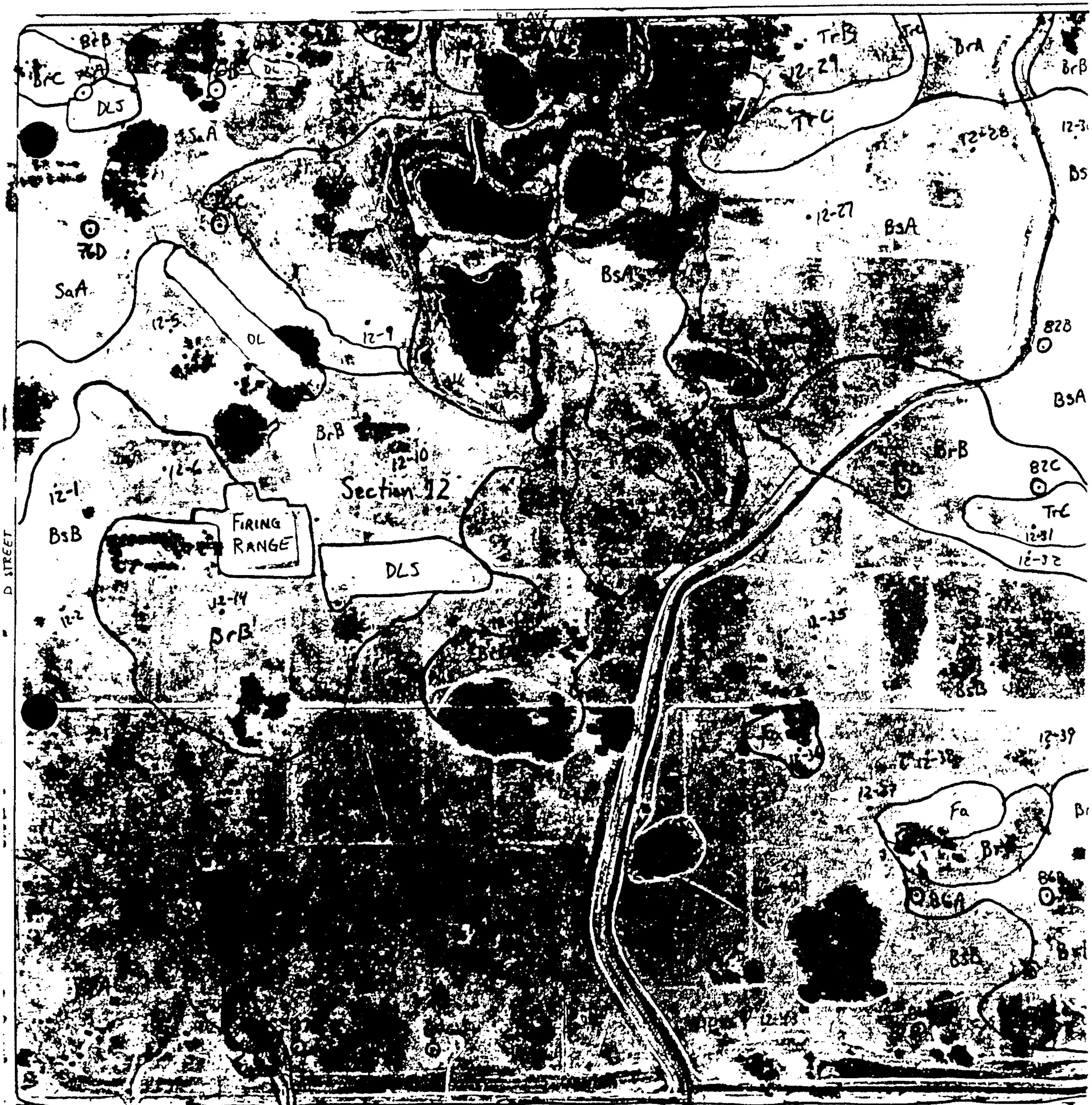

Limit of Soil Survey

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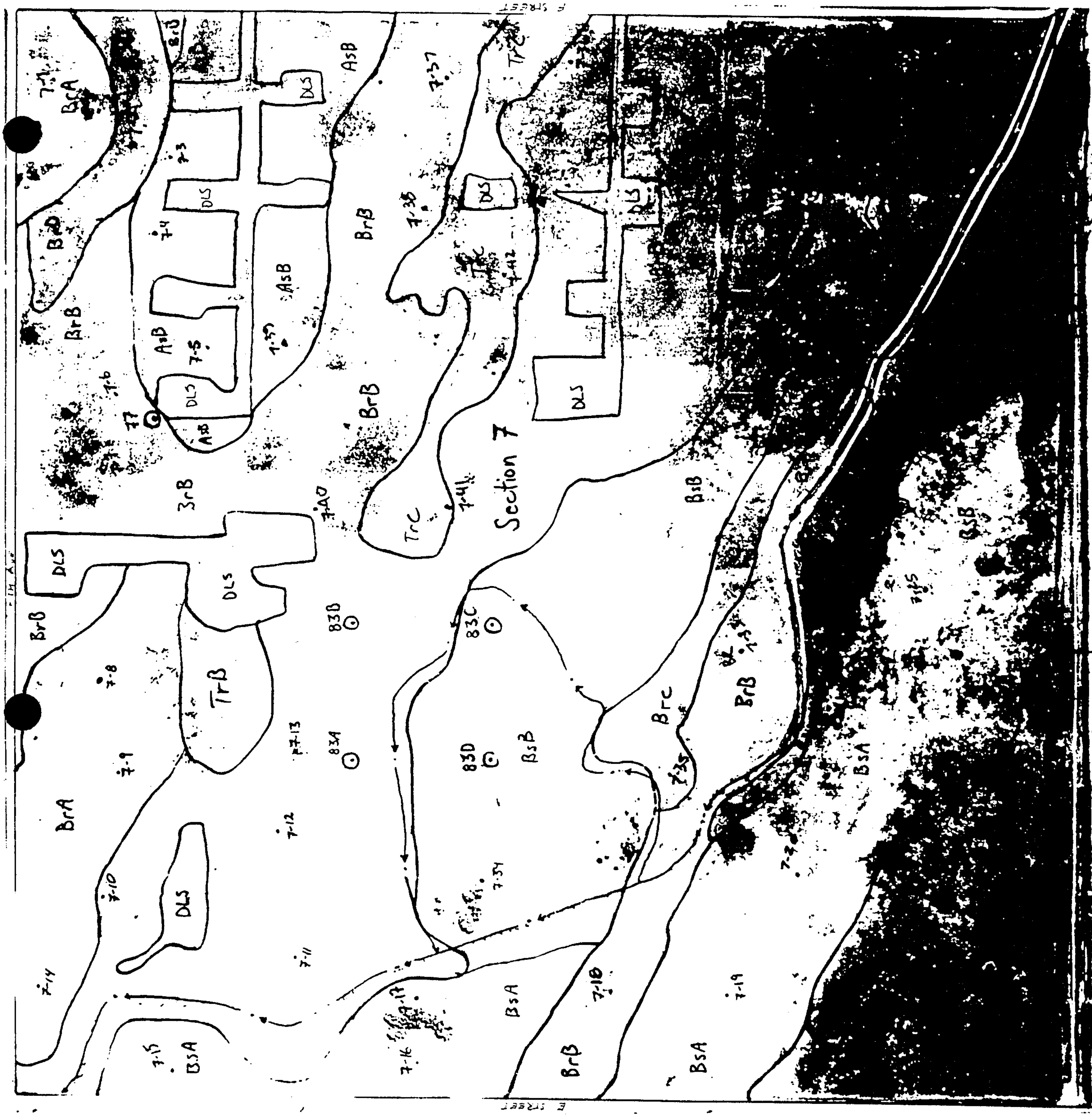

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BrA
BrB
DLS
Th
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8-19
8-20
8-34
8-16
84A
84B
84C
84D
AsB
Fa
BrC
Section
8-21
8-22
8-23
TrB
WeA
8-29
8-24
TrA
8-25
8-26
8-28
TrC
E 56th Ave.
Limit of Soil Survey
E 56th Ave.
DLS